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OPERATION MANUAL

ENERGY STORAGE SYSTEM

PCS ESS

GENERIC

Based On			Doc. Type	TECHNICAL DESCRIPTION	
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1. PURPOSE

The purpose of this document is to guide the system operators on how to use and operate the ABB Power Conversion System (PCS) equipped with the ABB Battery Storage Utilization (BSU) application via the ABB touch screen local control panel PP835.

The ABB BSU application is designed to test capabilities of the Battery Energy Storage (BES) and also could improve existing utility power delivery under various load changing conditions. This document describes the currently implemented modes of operation and explains the system interface between the ABB and the Customer systems.

The ABB Battery Energy Storage System (BESS) can also be controlled by the remote PLC system and that is not covered by this Operation Instruction.

2. SCREENS SUMMARY

Four lineups is the maximum which can be supported by the ABB standard BESS design. Depending on the number of lineups available in a particular system, certain pages and information may not be applicable. This specific manual will cover only one lineup screen.

There are six types of screens:

- Navigation Screens do not display any system information and are used as gateways to access other screens. These screens are:
    - ***MAIN SELECT*** – default screen when system start first time.

- Individual Lineup Overview Screens. Contain detailed overview information for all individual subsystems (lineups systems, batteries systems, enclosure etc.). These screens are:

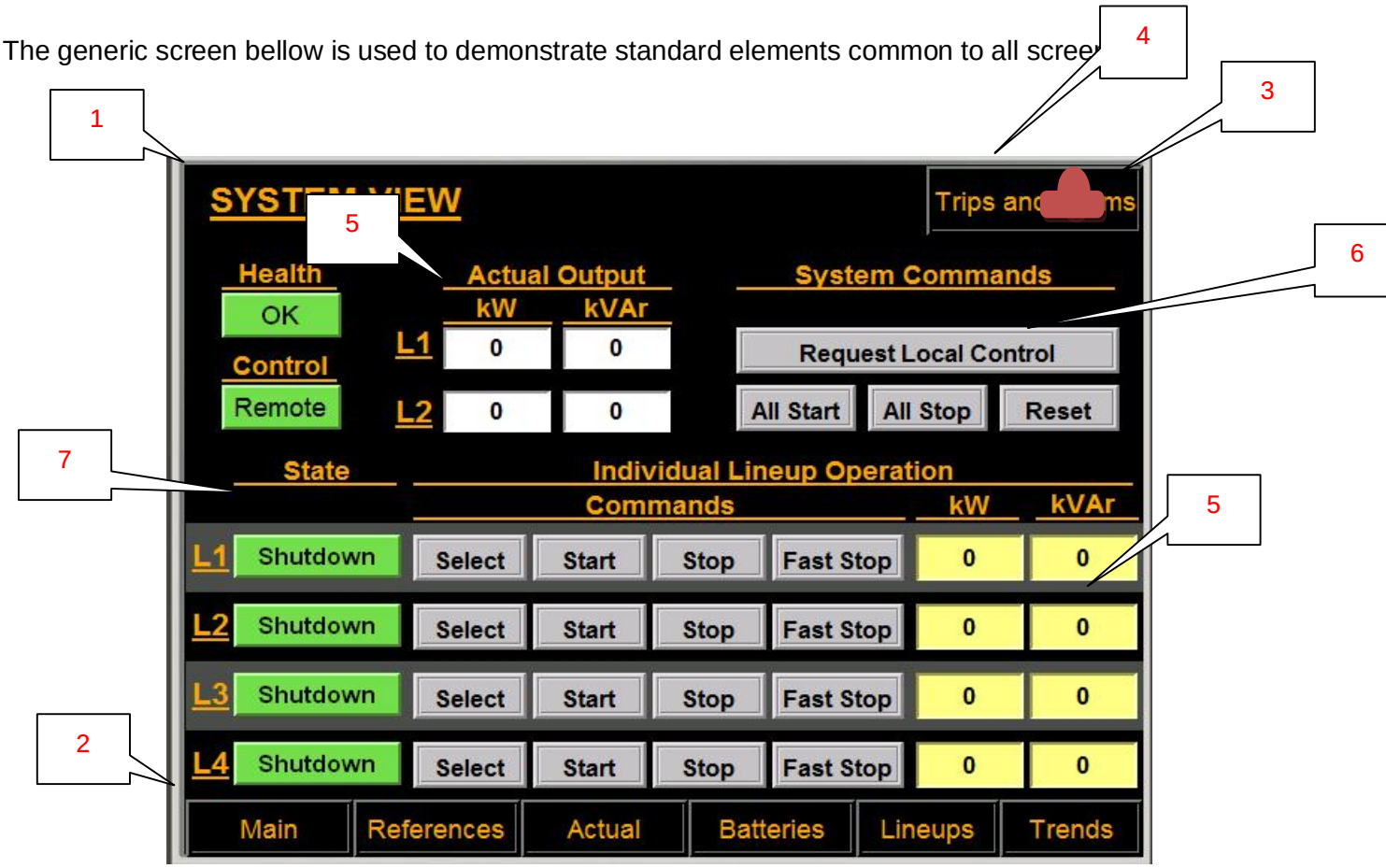
- o ***L1 VIEW*** - contains all information regarding single lineup. This includes AC and DC breakers position as well as inverters and batteries status. This screen shows the reference chain from requested reference until actual reference provided to inverters.

- System Control Screen contains operator interface buttons required to select, start and stop the system. This screen is:
  - o ***SYSTEM START*** – contains system indication, selection and control operator interface buttons.
- Trend Screens contain real time plots for certain information. These screens are:
  - o ***L1 TREND***
- Trip and Alarm screen is the screen where all alarm and trip messages are displayed and therefore it is the primary troubleshooting tool in the event of system failure. All Alarm and Trip messages are listed and explained at the end of this manual. Trip and Alarm screen can be accessed from any screen in the process panel by the button on the top right hand corner. Red blinking bell indication on the upper right corner is indication of the new active alarm. This screen is:
  - o ***TRIPS AND ALARMS***

- BSU (Battery Storage Utilization) screens. This application screen contains operator selection and overview screens required to control and run various controlled modes described in details latter on. This screens are:
  - o ***MODE 1***
  - o ***MODE 2***
  - o ***MODE 3***
  - o ***MODE 4***
  - o ***WORK DAY SCHEDULE***
  - o ***SATURDAY SCHEDULE***
  - o ***SUNDAY SCHEDULE***

3. STANDARD SCREEN LAYOUT OVERVIEW

The generic screen bellow is used to demonstrate standard elements common to all scree



Screen Name:

The title of the current screen is always displayed at the top right corner of the screen in large capital letters; the name of the screen shown above is ***SYSTEM VIEW*** for example.

Navigation Buttons:

These buttons are black framed boxes with orange font. Every screen has a bar at the bottom of the screen with a number of navigation buttons. These buttons are used to access different screens. The available navigations buttons are usually different for each screen. Each screen will have a Main button at the bottom left corner which allows them to return to the Main Select welcome screen.

Active Trip or Alarm Indication:

Whenever there is new alarm or trip event a red graphic bell will flash in the top right corner of all screens. The bell disappears if all alarm and trip events are acknowledged.

Trips and Alarms Navigation Buttons:

Every screen without exception has a Trips and Alarms navigation button on the top right of the screen. This screen allows access to the Trips and Alarms page which displays fault messages for the entire system.

Number Fields:

Those fields are either with yellow or white background.
White background fields display information from the system to the operator.
Yellow background fields however are designed for the operator to input numerical values for the control system. To enter a value, press on the desired field to have a number pad pop up.

Control Buttons:

These buttons are grey framed boxes with black font. In the screen above there are 20 buttons with various commands.

Health or State Icons

There are various icons used to display status information. Status icons can change both background color and writing. The green boxes above are examples of these icons.

- Health Icons: are used to indicate either system or lineup health. The health icons have 3 possible states:

  For System:

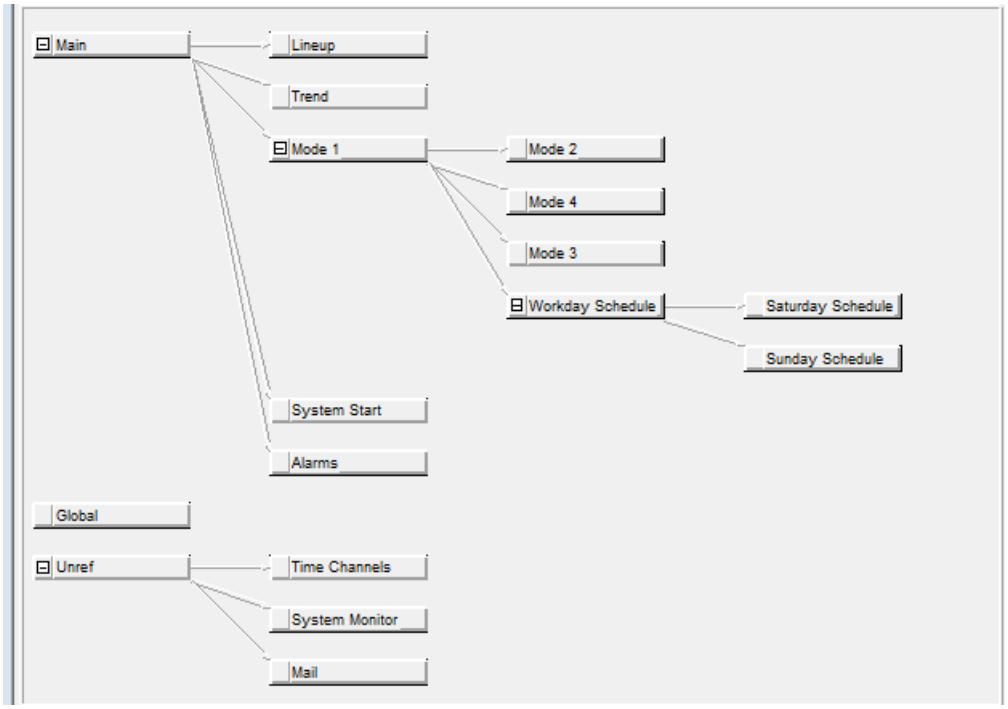
  - **OK:** indicates that there is no problem with the system, including all lineups.
  - **Alarm:** indicates an active alarm anywhere within the system. System running at reduced capacity due to a lineup trip is also considered and alarm.
  - **Fault:** indicates that the entire system is faulted and therefore tripped.

  For a lineup:

  - **OK:** indicates that there is no problem with the lineup.
  - **Alarm:** indicates an active alarm within the lineup.
  - **Fault:** indicates that lineup has experienced a serious fault and is tripped.

- Lineup State Icons: are used to indicate lineup operational status. There are 6 possible status icons.
  - **Shutdown:** indicates that AC and DC breakers are opened and inverters are stopped.
  - **Ready:** indicates that lineup is shutdown but ready to receive enable command.
  - **Enabled:** indicates that the lineup is ready to receive run command.
  - **Online:** indicates that lineup is ready to receive a power reference.
  - **Standby:** unit has slipped into standby mode if power reference was below standby limit for defined time.
  - **Transition:** lineup is a transition state between the defined states.

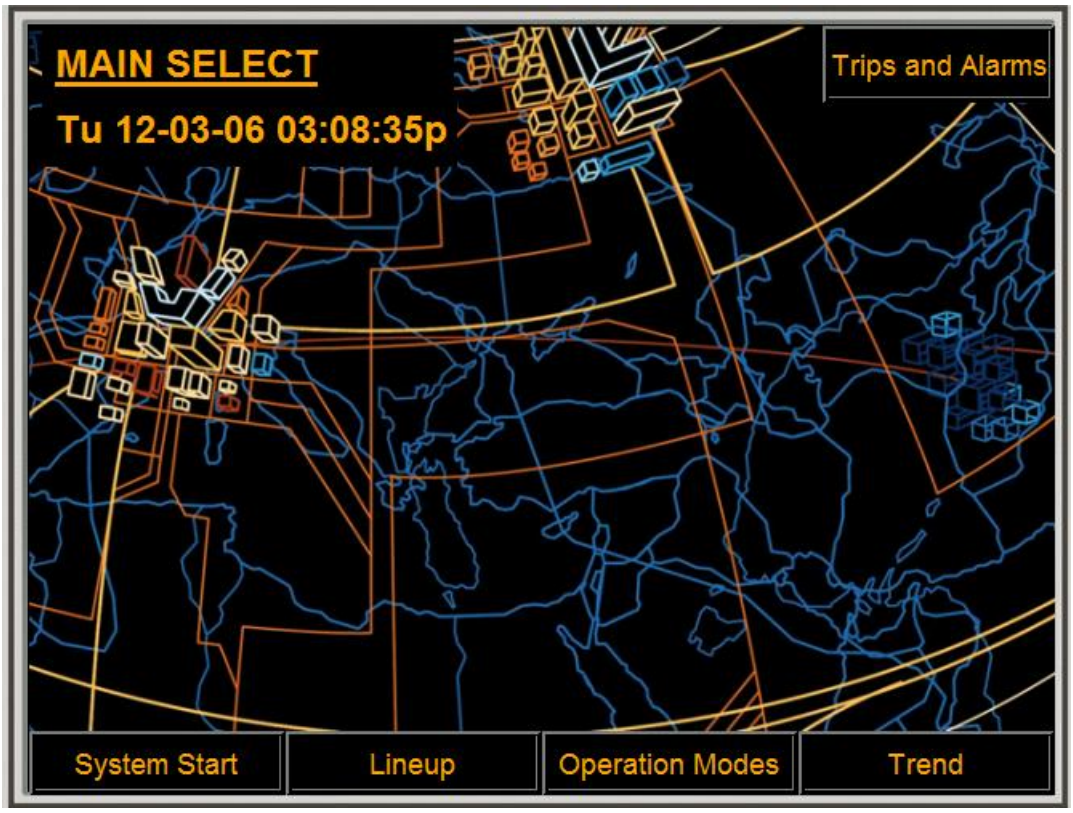
4. NAVIGATION OVERVIEW



This chart explains interconnection and selection options between individual screens. Each screen always has access to the ***MAIN SELECT*** screen and ***TRIPS AND ALARMS*** screen.

5. STANDARD SCREENS

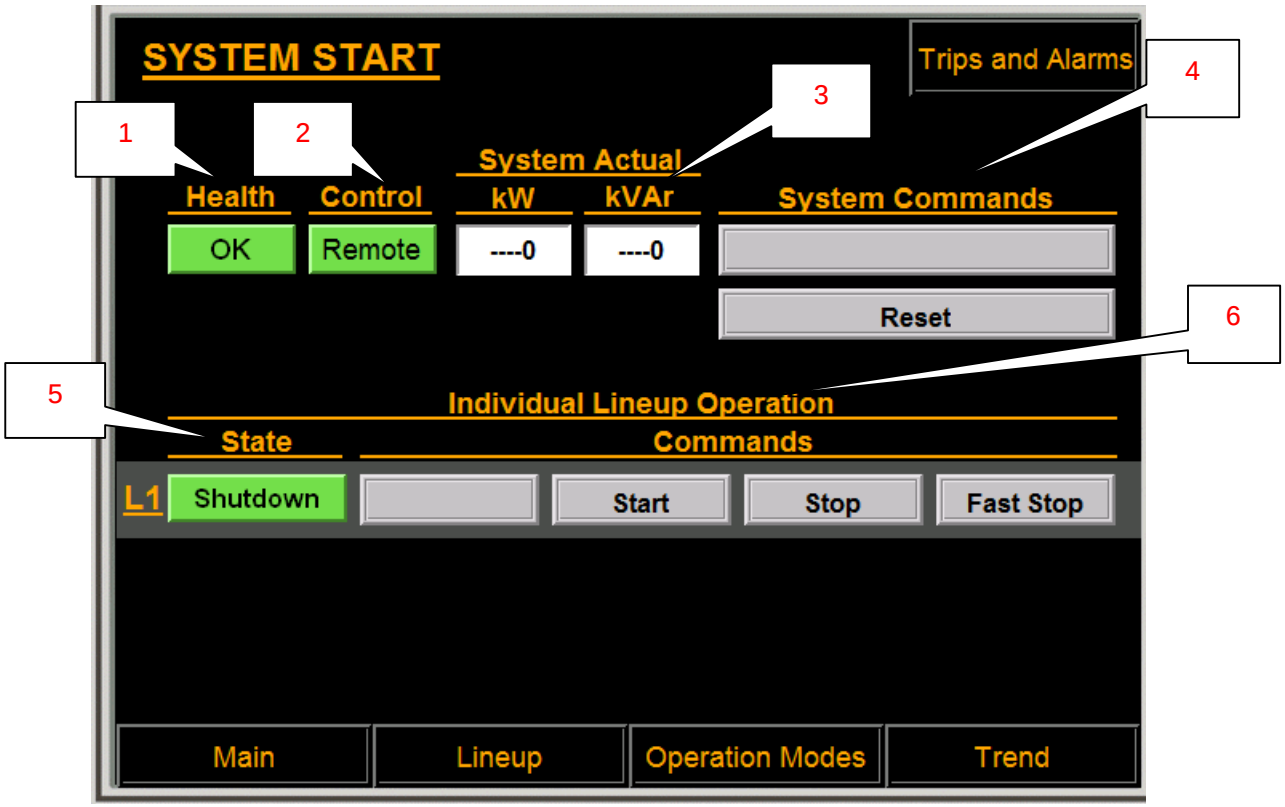
5.1 MAIN SELECT



This is a main navigation screen as well as the welcome screen each time system is powered up. The following screens can be accessed from ***MAIN SELECT*** screen:

- ***SYSTEM START***
- ***LINEUP***
- ***OPERATION MODES***
- ***TREND***

5.2 SYSTEM START



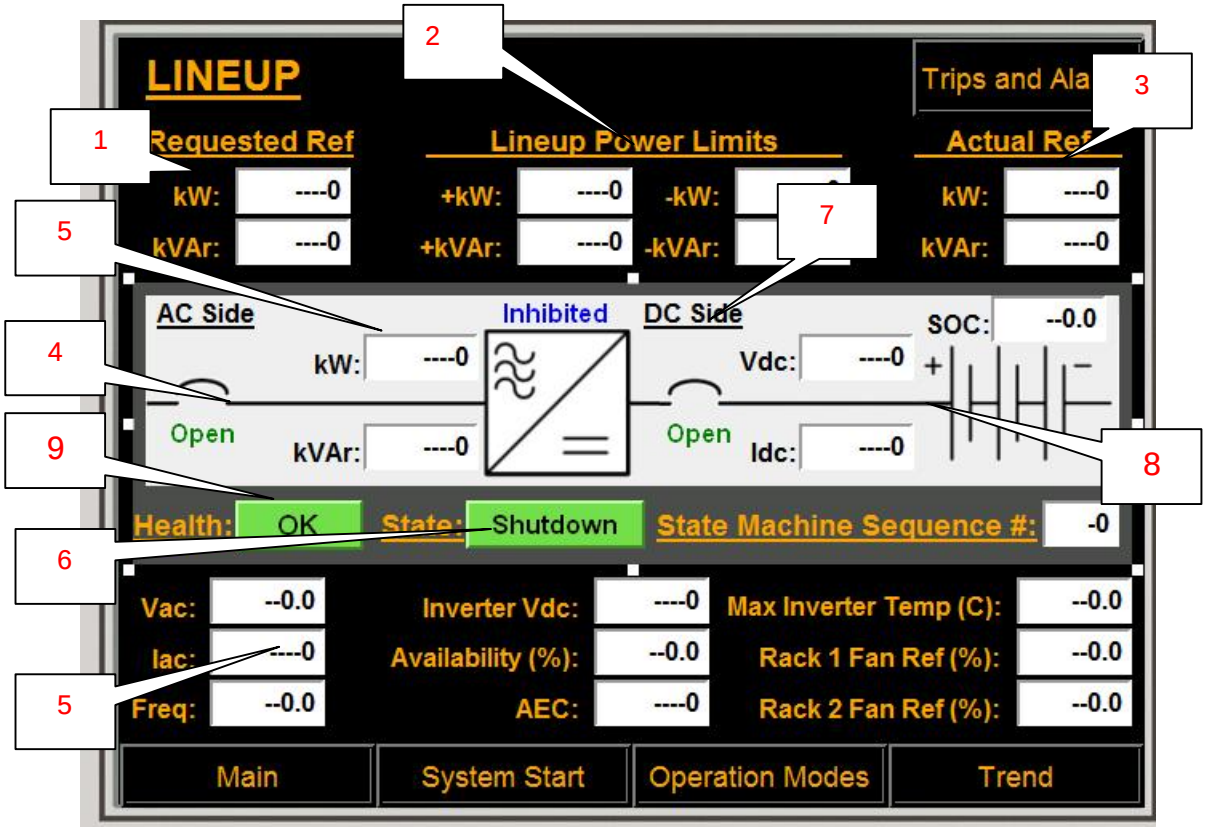
This screen offers basic overview for the entire system. Also this is the only screen that can be used for Local system control. Depending on system configuration, different buttons will be available.

1. **Health**
   - **OK** – System is OK
   - **Alarm** – System Alarm present. Check Alarm List
   - **Fault** – System Fault condition present. Check Alarm List
2. **Control**
   - **Remote** - System is taking commands from remote client communication (not covered with this manual).
   - **Local** – ABB Battery Energy Storage System (BESS) is controlled via this ABB touch screen local control panel PP835.

3. **Actual Output**
    - **kW** – Actual Lineup Active Power
    - **kVAr** – Actual Lineup Reactive Power
4. **System Commands**
    - **Request Local Control** - is used to place the system into local operator panel control. This button is also used to release control back to remote.
    - **Reset** - Command is used to reset system faults. A system fault can only be reset if the fault condition is cleared.
5. **State**

    There are 6 possible status icons.
    - **Shutdown** - AC and DC breakers are opened and inverters are stopped.
    - **Ready** - Lineup is at shutdown but ready to receive enable command.
    - **Enabled** - Lineup is ready to receive run command.
    - **Online** - Lineup is ready to receive a power reference.
    - **Standby** - Lineup has slipped into standby mode if power reference was below standby limit for defined time.
    - **Transition** - Lineup is at transition state between the defined states.
6. **Individual Lineup Operations**
    - **Select** – Select or Deselect Lineup to run.
    - **Start** - Command will start individual lineup only if selected.
    - **Stop** - Command will soft stop corresponding lineup with programmable ramp.
    - **Fast Stop** - Command will fast stop corresponding lineup – Stop without ramp.

5.3 INDIVIDUAL LINEUP VIEW



This screen offers all relevant information for the lineup.

1. **Requested Ref**

   This is raw reference to the lineup from the system level.

   - **KW** - Lineup Active power (positive is power out to the grid therefore discharging batteries and negative is power in from the grid therefore charging batteries).
   - **KVAr** - Lineup Reactive power: (positive is capacitive and negative is inductive reactive power).

2. **Lineup Power Limits**

   Power limits used by the lineup to limit the reference if the reference is beyond available lineup power. Available power is a function of batteries status, inverter status and temperature.

- +**kW** – Lineup Active Power Limit during charge mode.
- -**kW** – Lineup Active Power Limit during discharge mode.
- +**kVAr** – Lineup Reactive Power Limit during charge mode.
- -**kVAr** – Lineup Reactive Power Limit during discharge mode.

3. **Actual Ref**

   Actual reference sent to the inverters.

   - **kW** – Actual Lineup Active Power Reference
   - **kVAr** – Actual Lineup Reactive Power Reference

4. **AC Breaker**

   Indication of the AC breaker actual position.

   - **Closed** – AC Breaker is closed
   - **Open** – AC Breaker is open
   - **Undefined** – AC breaker position is not defined. This indication will result with system trip.

5. **Actual Power Output**

   Following fields are Indicating actual lineup power output in kW and kVAr reported by the inverter.

   - **kW** - Lineup Active power (positive is power out to the grid therefore discharging batteries and negative is power in from the grid therefore charging batteries).
   - **kVAr** - Lineup Reactive power: (positive is capacitive and negative is inductive reactive power).
   - **Vac** – Lineup inverter average three phase AC voltage.
   - **Iac** – Lineup inverter average three phase AC current
   - **Freq** – Lineup output AC frequency.
   - **Vdc** – Lineup inverter DC link voltage.
   - **Availability** – Lineup percentage of inverter modules available, 100% is full availability and normal status.
   - **AEC** – Lineup active event code, error and status code from the inverters. Please refer to PCS100 ESS manual for detailed definition of active event codes.
   - **Max Inverter Temp** – Maximum inverter heat sink temperature of any inverter module in the lineup. .
   - **Rack 1 Fan Ref** – Speed reference for the individual rack cooling fans
   - **Rack 2 Fan Ref** – Speed reference for the individual rack cooling fans

- **State Machine Sequence** – Indication of the lineup active sequence number

6. **Lineup State**

   There are 6 possible status icons.

   - **Shutdown** - AC and DC breakers are opened and inverters are stopped.
   - **Ready** - Lineup is at shutdown but ready to receive enable command.
   - **Enabled** - Lineup is ready to receive run command.
   - **Online** - Lineup is ready to receive a power reference.
   - **Standby** - Lineup has slipped into standby mode if power reference was below standby limit for defined time.
   - **Transition** - Lineup is at transition state between the defined states.

7. **DC Breaker**

   Indication of the DC breaker actual position.

   - **Closed** – DC Breaker is closed
   - **Open** – DC Breaker is open
   - **Undefined** – DC breaker position is not defined. This indication will result with system trip.

8. **Batteries Actual Values**

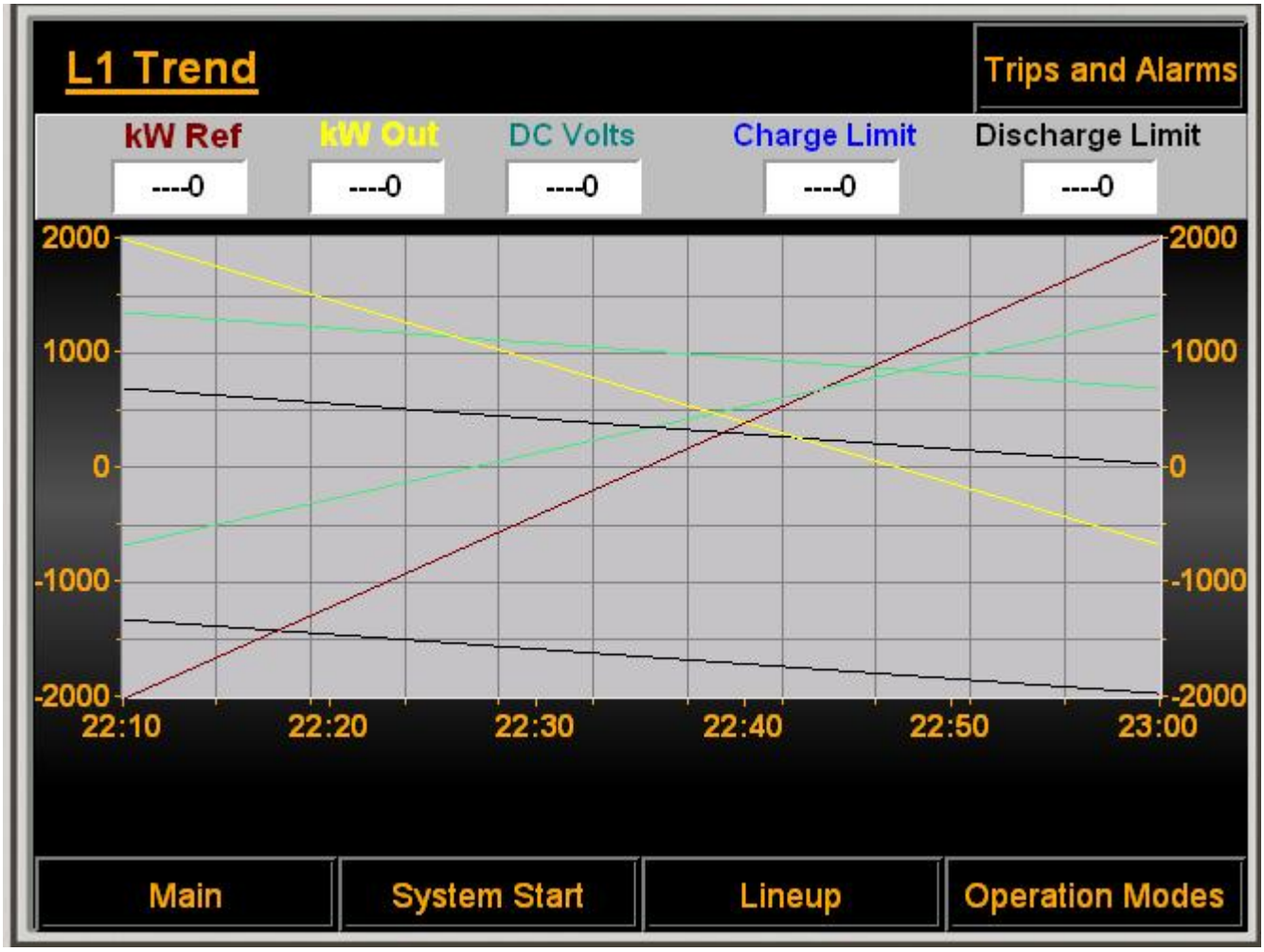
   - **Vdc:** batteries DC voltage.
   - **Idc:** batteries DC current flow.
   - **SOC:** battery state of charge.

9. **Health**.

   This is just indication of compete lineup status and for more information please check Alarm and Trip screen.

   - **OK** – System is OK
   - **Alarm** – System Alarm present. Check Alarm List
   - **Fault** – System Fault condition present. Check Alarm List

5.4 LINEUP TREND



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This trend window provides real time trend for the following lineup level signals:

- **Lineup kW Ref**: total system real power reference.
- **Lineup kW Out**: total system real power output
- **Lineup DC Voltage**: actual battery DC voltage.
- **Charge Current Limit**: maximum allowable charging current. This value is provided by battery management system.

- **Discharge Current Limit:** maximum allowable discharge current. This value is provided by battery management system.

Trend windows are set by default to store 10000 samples at a sampling rate of 30 seconds. Therefore it is possible to view historical data for approximately 82 hours. Trends are continuously running and it is not possible to stop trending.

5.5 TRIPS AND ALARM DISPLAY

This is the trips and alarms list screen. All trip and alarm event information messages are sent to this screen therefore it is the primary troubleshooting tool.

- **ESC Button** - Return to the previous screen.
- **Up and Down Arrow Buttons -** Used for scrolling up and down the events list.
- **Check Button -** Used to acknowledge and alarm or trip event.
- **Magnifying Glass Button** - Used to change font size of the event text. Continuous pressing this button will circle text size to the original text size.
- **Reset Button** - Reset command to clear all trip and alarm events. Events are only cleared if the root cause is no longer in effect.
- **Watch Button** - Used to toggle present On and Off event time stamps.

6. ALARMS AND TRIP LIST - FAULT CODES

Table below contains full list of ABB Battery Energy Storage System (BESS) Trip and Alarm messages and basic troubleshooting instructions.

ABB PCS100 User manual must also be used in conjunction with this list in most of the cases.

If listed troubleshooting tips do not resolve the problem please contact ABB help line for further assistance.

NOTE:

- T letter leading display message indicate Trip message
- A letter leading display message indicate Alarm message

Fault Code	Message	Full Description and Action
FC0000	**T AC Safeties Bypass**	Trip -System Started while AC breaker is in simulation mode through the interactive window and all safety logic has been temporary bypassed. Disable AC Breaker Simulation Mode.
FC0001	**T AC Unexpected Status**	Trip, position contact feedbacks are not as expected by the command output for more than 500ms. This is either indicating breaker or auxiliary contact feedback failure. Using simulation mode test breaker and check breaker feedback.
FC0002	**T AC Operation Fault**	Trip, breaker did not complete either open or closed operation within 500ms after a command was given. Using simulation mode test breaker and check breaker feedback.
FC0003	**T AC OCP Relay Trip**	Trip, breaker tripped by over current protection relay. Check LV system between transformer secondary and PCS incoming terminals for short circuit. Check system PCS100 system for faults and use PCS100 User Manual for system troubleshooting.
FC0004	**T AC Racked Out**	Trip, breaker is racked out position. Rack circuit breaker to connected position and verify that circuit breaker is locked in connected position.

		Check aux. contact feedback for the circuit breaker position.
FC0050	**A Breaker Module Simulation Active**	Alarm, breaker control module is in simulation mode through interactive window. Disable AC Breaker Simulation Mode.
FC0100	**T DC Safeties Bypass**	Trip -System Started while DC breaker is in simulation mode through the interactive window and all safety logic has been temporary bypassed. Disable DC Breaker Simulation Mode.
FC0101	**T DC Unexpected Status**	Trip, position contact feedbacks are not as expected by the command output for more than 500ms. This is either indicating breaker or auxiliary contact feedback failure. Using simulation mode test breaker and check breaker feedback.
FC0102	**T DC Operation Fault**	Trip, breaker did not complete either open or closed operation within 500ms after a command was given. Using simulation mode test breaker and check breaker feedback.
FC0103	**T DC OCP Relay Trip**	Trip, breaker tripped by over current protection relay. Check DC cables between PCS100 and battery systems for short circuit and ground fault. Check system PCS100 system for faults and use PCS100 User Manual for system troubleshooting.
FC0104	**T DC Racked Out**	Trip, breaker is racked out position. Rack circuit breaker to connected position and verify that circuit breaker is locked in connected position. Check aux. contact feedback for the circuit breaker position.
FC0150	**A Breaker Module Simulation Active**	Alarm, breaker control module is in simulation mode through interactive window. Disable AC Breaker Simulation Mode.
FC0200	**T Ground Fault Resistivity trip level**	Trip, ground fault detection relay has detected ground fault trip level. Check system insulation to ground for possible damage. Check ground fault relay operation and setting.
FC0250	**A Ground Fault Resistivity alarm level**	Alarm, ground fault detection relay has detected ground fault trip level. Check system insulation to ground for possible damage.

		Check ground fault relay operation and setting.
FC0300	**A VFD Control Module Simulation Active**	Alarm, VFD control module for PCS100 cooling fans speed reference is in simulation mode through interactive window. Disable VFD Simulation Mode.
FC1000	**T DC Breaker Trip Unit Breaker Opened**	Trip, DC circuit breaker 50/51 current protection unit trip. Check DC cables between PCS100 and battery systems for short circuit and ground fault. Check system PCS100 system for faults and use PCS100 User Manual for system troubleshooting.
FC1001	**T Converter Room Door Opened**	Trip, converter room door is opened. Close convertor room door.
FC1002	**T Transformer Room Door Opened**	Trip, transformer room door is opened. Close transformer room door.
FC1003	**T Estop Pushbutton Active**	Trip, Emergency stop button has been pressed. Verify reasons for Estop push button activation and if system is ready for operation release Estop pushbutton.
FC1004	**T Smoke Detected**	Trip, smoke detectors are indicating smoke in container. Check system for damage. Verify smoke detectors are not malfunctioning.
FC1005	**T Transformer Temperature High**	Trip, transformer trip level temperature switch has activated. Check that transformer ambient air flow is free flowing and that all main cooling fans are operating. Check that transformer cooling is not obstructed. Verify that transformer temperature protection is not malfunctioning. If problem persists further transformer evaluations required. Please call ABB Service for more help.
FC1006	**T Transformer Differential Protection**	Trip, transformer differential protection trip. Check system for ground fault. If problem persists further transformer evaluations required. Please call ABB Service for more help.
FC1007	**T Transformer Protection Relay**	Trip, transformer additional protection relay has tripped. Check MV supply system for short circuit and ground fault. If problem persists further transformer evaluations required. Please call ABB Service for more help.

FC1050	**A Controller, Communication Module Breaker Opened**	Alarm, circuit breaker to the AC800M controller and modem has opened. Check components and wiring for short circuit.
FC1051	**A Fan 1 Fault**	Alarm, fault indication from fan 1. Check that power supply to the fan is OK. Verify that fan current is within the nominal tolerance. Use maintenance screen to run the cooling fan and verify that there is no obstruction to the air flow, fan is free spinning and that bearings are not damaged. If problem persists replace the fan.
FC1052	**A Fan 2 Fault**	Alarm, fault indication from fan 2. Check that power supply to the fan is OK. Verify that fan current is within the nominal tolerance. Use maintenance screen to run the cooling fan and verify that there is no obstruction to the air flow, fan is free spinning and that bearings are not damaged. If problem persists replace the fan.
FC1053	**A Fan 3 Fault**	Alarm, fault indication from fan 3. Check that power supply to the fan is OK. Verify that fan current is within the nominal tolerance. Use maintenance screen to run the cooling fan and verify that there is no obstruction to the air flow, fan is free spinning and that bearings are not damaged. If problem persists replace the fan.
FC1054	**A Fan 4 Fault**	Alarm, fault indication from fan 4. Check that power supply to the fan is OK. Verify that fan current is within the nominal tolerance. Use maintenance screen to run the cooling fan and verify that there is no obstruction to the air flow, fan is free spinning and that bearings are not damaged. If problem persists replace the fan.
FC1055	**A IO Modules Circuit Breaker Opened**	Alarm, circuit breaker to S800 IO cluster is opened. Check IO Module is not shorted. Check all IO for short circuit and ground fault. Replace damaged component if necessary.
FC1056	**A Transformer**	Alarm, transformer alarm level temperature switch has

	Temperature High	activated. Check that transformer ambient air flow is free flowing and that all main cooling fans are operating. Check that transformer cooling is not obstructed. Verify that transformer temperature protection is not malfunctioning. If problem persists further transformer evaluations required. Please call ABB Service for more help.
FC1057	**A UPS 120V Circuit Breaker Opened**	Alarm, circuit breaker on UPS 120Vac is opened. Check components and wiring for short circuit.
FC1058	**A UPS Running on Battery**	Alarm, UPS has lost main power and is running on battery.
FC1059	**A Air Temperature High**	Alarm, enclosure air temperature is high. Check air inlet filters and replace if necessary. Check main air cooling fans for proper operation.
FC1060	**A Air Humidity High**	Alarm, enclosure air humidity is high. Check that enclosure heaters are operational and replace if needed.
FC1061	**A Enclosure Module Simulation Active**	Alarm, enclosure supervision control module is in simulation mode through interactive window. Disable Enclosure Simulation mode.
FC1062	**A Control Box Temperature Low**	Alarm, temperature low in control box. Check control box heater and replace if necessary
FC1063	**A Fans Overload Protection Tripped**	Alarm, fans overload current protection tripped. Check cooling fans and replace if necessary.
FC1064	**A Air Temperature Low**	Alarm, enclosure air temperature low. Check enclosure heaters and replace if necessary
FC1100	**T Modem Module Failure**	Trip, communication modem has failed. Check modem and replace if necessary.
FC1101	**T IO Module Failure**	Trip, IO module has failed. Check IO modules and replace failed component.
FC1150	**A PM Warning**	Alarm, processor module has failed. Check module and replace if necessary.
FC1151	**A Slave Communication Down**	Alarm, Communication problem with slave reported from hardware. Check module and replace if necessary.

FC2000	**T Battery Fault**	Trip, fault indication from battery management system. Check BMS fault log. Refer to BMS troubleshooting guide for detailed troubleshooting instructions.
FC2001	**T Battery Communication Loss**	Trip, communication lost between ABB PLC and battery management system. Check that both systems are up and running. Check communication interface HW for faults.
FC2050	**A Battery Alarm**	Alarm, fault indication from battery management system. Check BMS alarm log. Refer to BMS troubleshooting guide for detailed troubleshooting instructions.
FC2051	**A Battery View Module Simulation Active**	Alarm, standard battery parameter communication module is in simulation mode through interactive window. Disable Battery Simulation mode.
FC2100	**T PCS Inverter Fault**	Trips, severe fault indication from PCS100 inverter system. See GDM active event code for more information. Use PCS100 User manual for fault remedy.
FC2101	**T PCS Inverter Comm. Loss**	Trip, communication lost between ABB PLC and PCS100 inverters. Check that both systems are up and running. Check communication interface HW for faults.
FC2150	**A PCS Inverter Warning**	Alarm, warning indication from PCS100 inverter system. See GDM active event code for more information. Use PCS100 User manual for fault remedy.
FC2151	**A PCS Inverter Derated**	Alarm, module failure in PCS100 inverter lineup resulting in reduced power availability. See GDM active event code for more information. Use PCS100 User manual for fault remedy.
FC2152	**A PCS Comm. Module Simulation Active**	Alarm, PCS100 communication control module is in simulation mode through interactive window. Disable PCS100 Simulation Mode.
FC2250	**A kW Output VS Reference Deviation**	Alarm, real power output is deviating from real power reference by amount defined in configurable parameters. Check available BES capacity
FC2251	**A KVAr Output VS Reference Deviation**	Alarm, reactive power output is deviating from real power reference by amount defined in configurable parameters. Check available BES capacity

FC2300	**T DC Voltage High**	Trip, battery DC voltage is above allowable limits. Restart the system and discharge the battery to the operating level.
FC2301	**T DC Voltage Low**	Trip, battery DC voltage is below allowable limits. Restart the system and charge the battery to the operating level.
FC2350	**A Lineup in Overload Cooldown**	Alarm, lineup has maxed out allowable overload operation and is therefore in cooldown mode. System power output will be automatically derated during cooldown period and no operator intervention is needed.
FC2351	**A Lineup Over Temperature Derated**	Alarm, enclosure temperature is too high therefore inverter lineups are derated. If ambient temperature inside enclosure is high check main cooling fans and inlet air filters. Check individual inverter cooling fans.
FC2352	**A Power Limit Module Simulation Active**	Alarm, Power Limiting control module is in simulation mode through interactive window. Disable Power Limiting simulation.
FC2450	**A Lineup Failed To Go To Standby**	Alarm, lineup failed to go to standby mode when standby command is high. Stop and start system again. Contact ABB for more information.
FC2451	**A Lineup Failed To Return From Standby**	Alarm, lineup failed to return from standby mode when standby command became disabled. Stop and start system again. Contact ABB for more information.
FC2500	**T Startup Fault**	Trip, a step in the startup sequence has timed out. Check HMI Alarm list for more details. Check that AC, DC Breakers and communication to the battery system is operational. Contact ABB if problem is not resolved.
FC2501	**T AC Breaker Open Unexpectedly**	Trip, AC breaker opened unexpectedly during online operation. Check AC breaker overload protection. Use maintenance display to test the breaker operation and breaker position feedback.

FC2502	**T Inverters Inhibited Unexpectedly**	Trip, inverters became inhibited unexpectedly during online operation. Check master module inhibit wiring and corresponding components.
FC2503	**T Inverters Not Running Unexpectedly**	Trip, inverters are not running as expected during online operation. See GDM active event code for more information. Use PCS100 User manual for fault remedy.
FC2504	**T DC Breaker Open Unexpectedly**	Trip, DC breaker opened unexpectedly during on line operation. Check AC breaker overload protection. Use maintenance display to test the breaker operation and breaker position feedback.
FC2505	**T Battery Vdc Too Low To Start**	Trip, battery DC voltage is too low to start inverter system. Charge batteries above minimum voltage level.
FC2550	**A State Machine Module Simulation Active**	Alarm, state machine control module is in simulation mode through interactive window. Disable State Machine Limiting simulation.
FC3050	**A Lineups Positive kW Availabilities Differ**	Positive real power availability differs between the lineups.
FC3051	**A Lineups Negative kW Availabilities Differ**	Negative real power availability differs between the lineups.
FC3052	**A Lineups Positive kVAr Availabilities Differ**	Positive reactive power availability differs between the lineups.
FC3053	**A Lineups Negative kVAr Availabilities Differ**	Negative reactive power availability differs between the lineups.
FC3054	**A System Startup Sequence Stalled**	Coordinated lineups startup sequence or shutdown has stalled.
FC3100	**T Process Panel Comm Loss on Local**	Trip, communication between HMI and ABB PLC has failed while system was in local control mode (control from the local HMI). Check communication and wiring between PLC and HMI.
FC3101	**A Process Panel Comm. Loss**	Alarm, communication between HMI and ABB PLC has failed when system was in remote control mode. (control by remote DCS). Check communication and wiring between PLC and HMI.

7. BATTERY STORAGE UTILIZATION (BSU) APPLICATION SOFTWARE

The ABB BSU application is designed to test capabilities of the Battery Energy Storage (BES) and also could improve existing utility power delivery under various load changing conditions. The BSU application software has four selectable modes of operations:

- ***Mode 1*** – Time Table Schedule (TTS) Mode
- ***Mode 2*** – Remote Control (RC) Mode
- ***Mode 3*** – Auto Peak Load Shaving (APLS) Mode
- ***Mode 4*** – Auto Load Smoothing Mode (ALS) Mode

Primary control of the ABB BSU application is by the operator from the remote location. All communication is over Modbus TCP/IP communication network. Operator is able to adjust set points and receive actual system values in the real time.

ABB BSU application can be also controlled locally by the local HMI control panel. This local control location is used during commissioning, troubleshooting or in case of the communication failure.

Both control locations have identical control features.

Mode of the operation selection or change can be done while the system is running but operator has to be aware of the implications if doing this change “on the fly”.

Set point control

For example If system is running in the Time Table Schedule **(TTS)** - ***(Mode 1)*** and operator decide to switch to the Remote Control **(RC)** – ***(Mode 2)*** the ABB control system will immediately use current RC - ***(Mode 2)*** P and Q Set points.

On the other hand If the system is running in Remote Control **(RC)** - ***Mode 2*** and operator decide to switch to the Time Table Schedule **(TTS)** - ***Mode 1*** system will keep running using **(RC)** - ***Mode 2*** Setpoint till first **(TTS)** - ***Mode 1*** break point become active.

Rate of rise (slope) control

Transition from current set point to new set point is controlled by the rate of rise (or slope) parameter. Active power slope dP/dt (kW/s) and reactive power slope dQ/dt (kVAr/s) are two important parameters defining how fast (If at all) system will transition between two set points.

For example if dP/dt = 50 (kW/s) the ABB BSU system will transfer from 0 to 500kW output in 10 seconds.

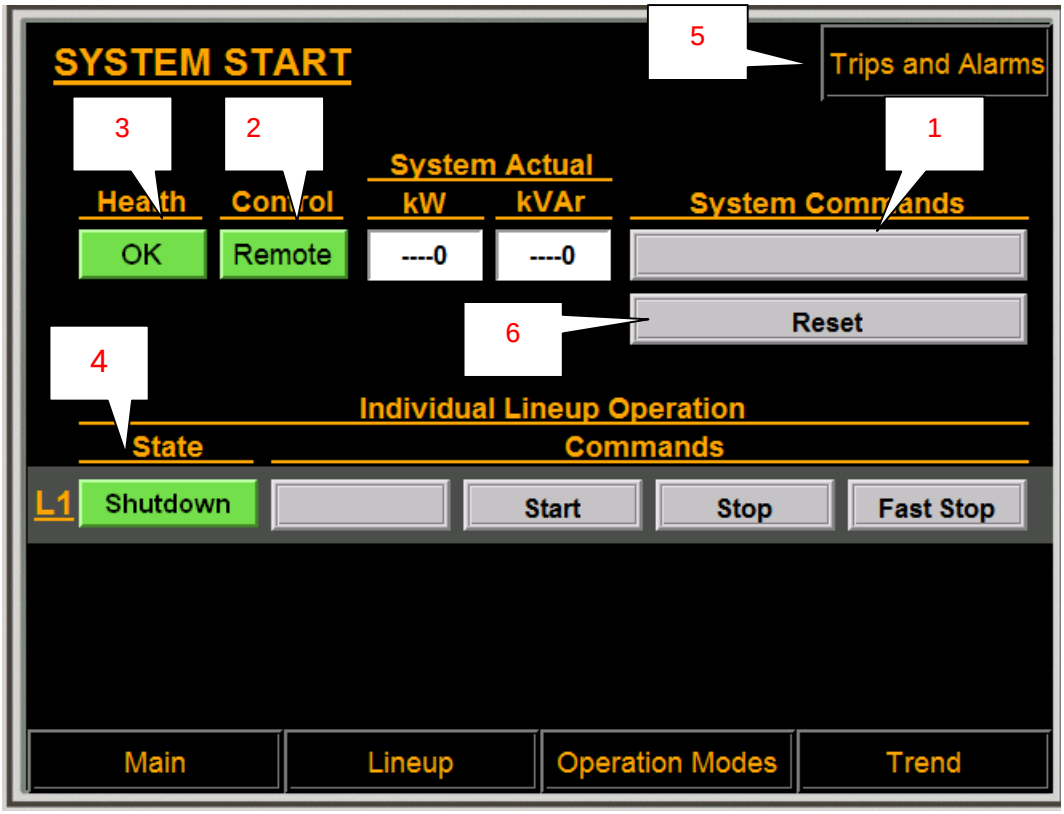
If dP/dt = 500 (kW/s) the ABB BSU system will transfer from 0 to 500kW output in one second.

If dP/dt value is 0 kW/s the ABB control system will not change output and system will keep current set point value.

7.1 Start the BSU System Locally from HMI

To start system from the local HMI follow these steps:

Select ***SYSTEM START*** display.

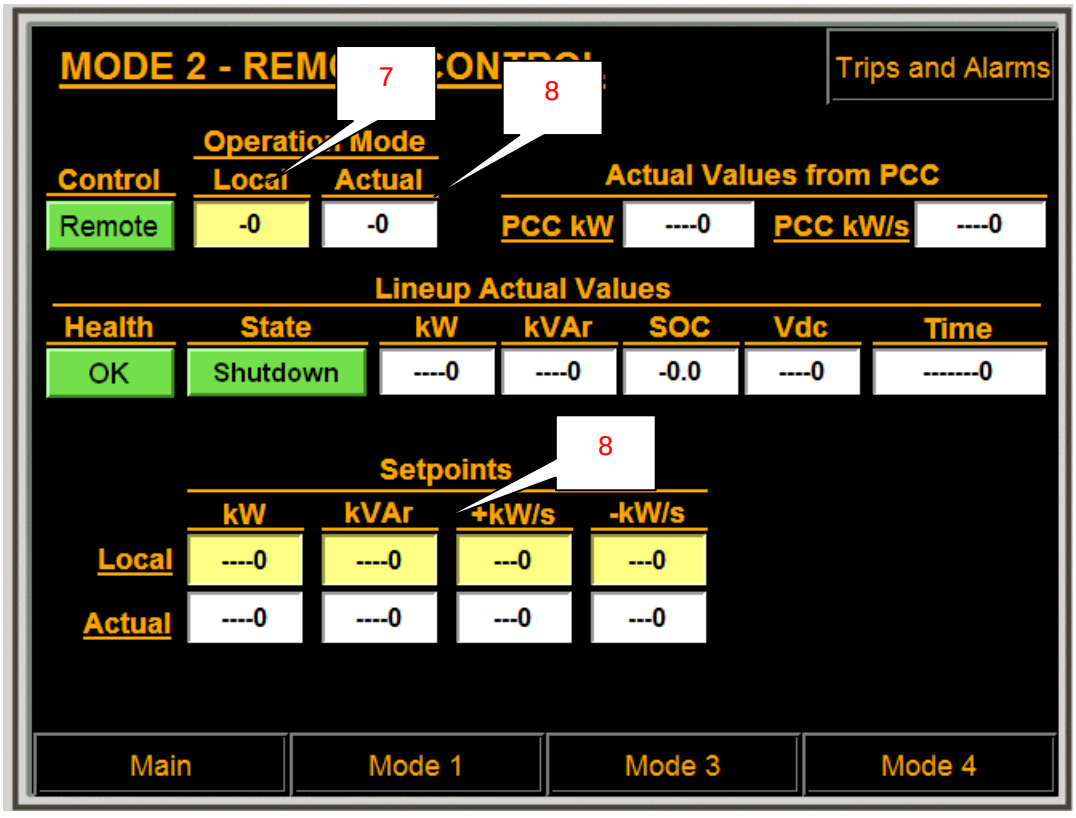


1. Set the control to **Local.**
2. Verify that system is in Local control mode.

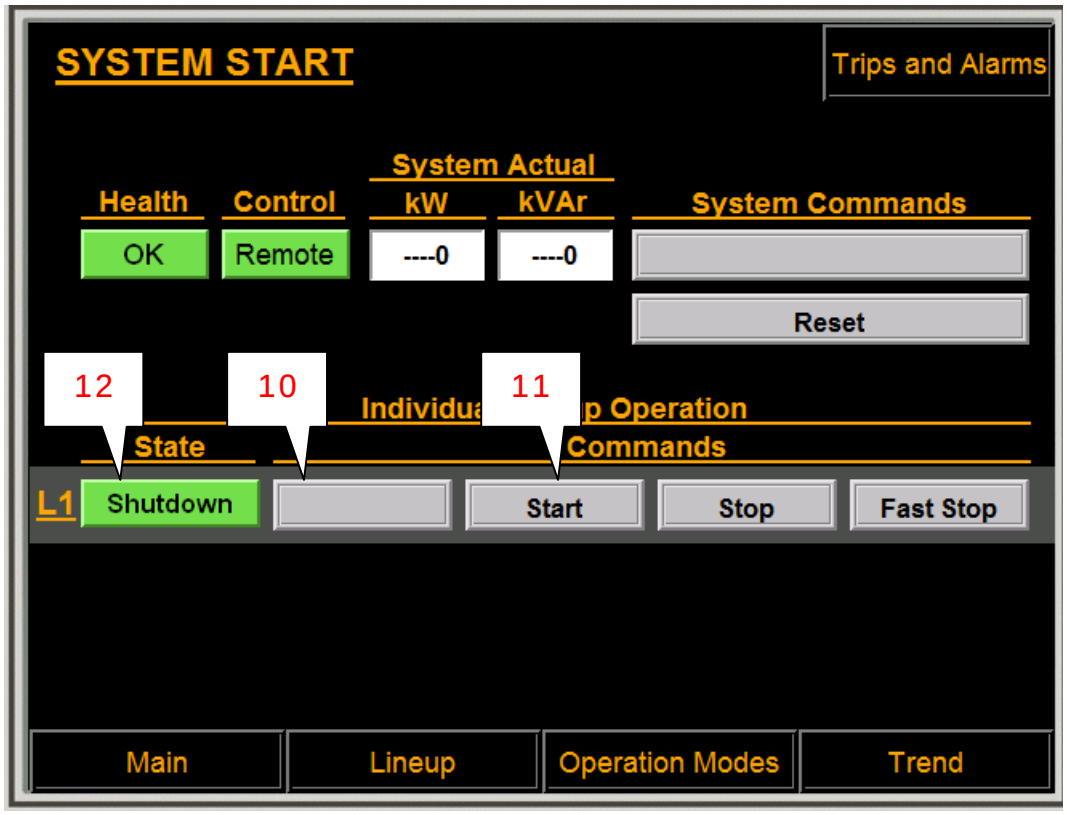
3. Check that system is Healthy – **OK** and **Alarm** value are permissive to Start the system.
4. Lineup must be at **Ready** state to Start the system.
5. If Health or State is indicating not ready as in 3 and 4 above check ***TRIPS AND ALARMS*** screen.
6. Use Reset button to reset latched faults if required. If fault is still active it is not possible to reset it. Next step is to select the desired mode of operation. For example operator will select RC – (***Mode 2)***

Select ***MODE 2 – REMOTE CONTROL*** display.

7. Set ***Local*** Operation Mode to 2.
8. Verify that ***Actual*** mode is 2.
9. Set ***Local*** set points to desired value. NOTE: Slope +/- kW/s must be different than zero for system to transition to the new set point.



Select ***SYSTEM START*** display.



10. Select the lineup to Start.

11. Start the lineup.

12. Verify that lineup is ***Online.***

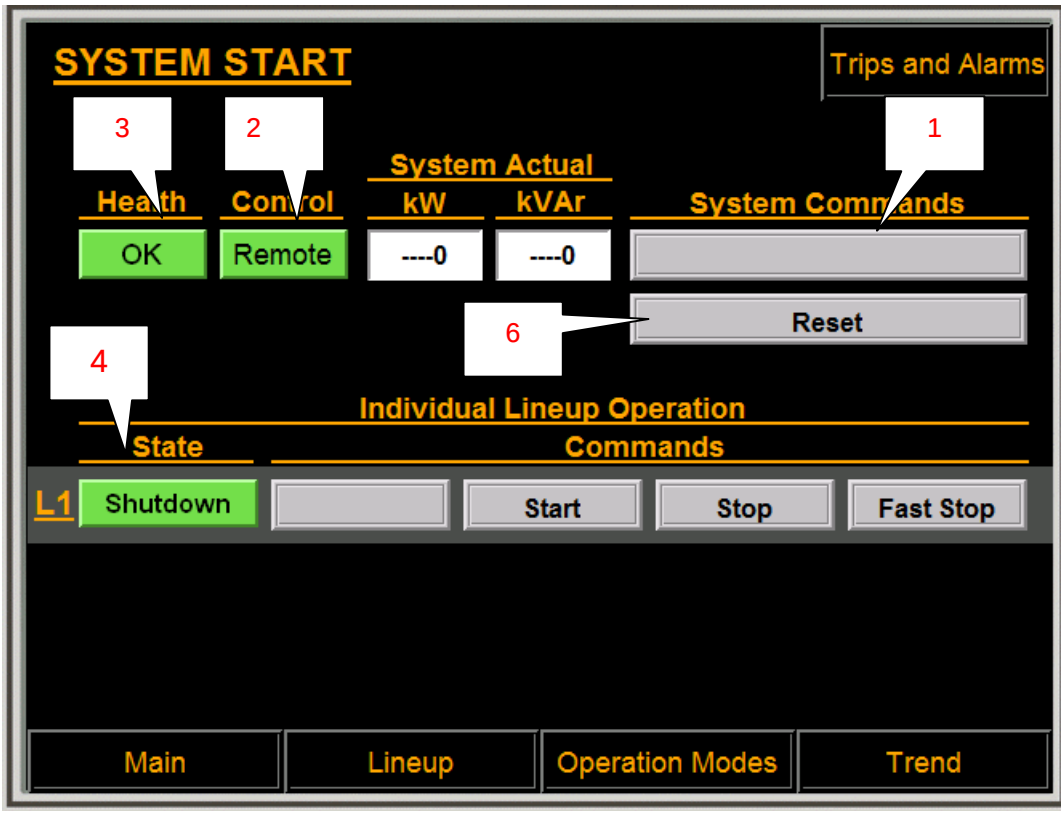
Select ***MODE 2 – REMOTE CONTROL*** display and continue running the system.

7.2 Remote Start of the BSU System

This section will cover just basic signals needed to start and stop the ABB BSU system from remote. Full list of signals and description is presented in the signals exchange list document that is proprietary for individual BES and the end customer DCS.

To start system from the Remote follow these steps:

Select ***SYSTEM START*** display.



1. Set the control to **Remote.**
2. Verify that system is in Remote control mode. For safety purpose it is not possible to switch to the Remote mode from remote location.

In the Remote mode of the operation the ABB system is controlled with use of the Main Control Word.

Name	Unit	Description
Main_Control_Word	bitfield	The Customer Main Control Word 0: Shutdown b1: Run b2: Reset b3: Heartbeat (1 sec) b4: Enable PCS b5: Time Pulse (NOT USED) b6: Read Table (NOT USED)

OM_r	kVAr	The Customer Request Mode of operation b0: No Selection b1: Timed Schedule b2: Remote Control b3: Peak Shave Automatic Mode b4: Load Smoothing Automatic Mode

Table – The Customer commands to the ABB

Name	Unit	Description
Status_Word	bitfield	b0: Lineup shutdown if bit = 1 , system not running. b1: Ready if bit = 1 , all permissive for lineup are good, ready to be enabled b2: Enabled if bit = 1, enable command from client received and acknowledged b3: AC breaker closed if bit = 1. b4: DC breaker closed if bit = 1. b5: Online if bit = 1, lineup is ready for reference. b6: Standby, DC breaker is closed but unit is not switching b7: Maintenance (commissioning mode), if commissioning mode enabled, control from client is disabled b8: Alarm from lineup b9: Trip from lineup b10: Heartbeat to client, used to determine communication health
OM	bitfield	b0: Peak Shave Fixed Time b1: Peak Shave by dispatch b2: Peak Shave Window Control b3: Load Smoothing
EV_Specific_Alarm_Word	bitfield	b0: PF Alarm 1 is active when actual PF requested by than operator cannot be achieved. b1: Desired SOC was reached during charge cycle (Reset when next

		charge cycle begins) b2: Desired SOC was NOT reached during charge cycle (Reset when next charge cycle begins)
Battery_Critical_Alarm	bitfield	b0: Low SOC b1: Over temperature (substring) b2: Under tempreature (substring) b3: Over voltage (substring) b4: Under voltage (substring) b5: Over current (substring) b6: Substring offline b7: String offline b8: Charging required b9: Balancing required b10: Battery module replacement required b11: Balancing in progress b12: Fan replacement required b13: Control module replacement required b14: Log file full

Table – The ABB Feedback to the Customer.

3. Verify that system is fault free. Check the ABB Status_Word and the Battery_Critical_Alarm words for fault indication.

4. Set the desired mode of operation OMr and verify the ABB system is reporting same mode back.

5. Using Main_Control_Word (MCW) select the system. (Set MCW to decimal 16)

6. Start the system (Set MCW to 18)

7. To Stop the system Set MCW bit 0 to 1. (Set MCW to 1 or 17).

Each mode specific details are described individually latter on.

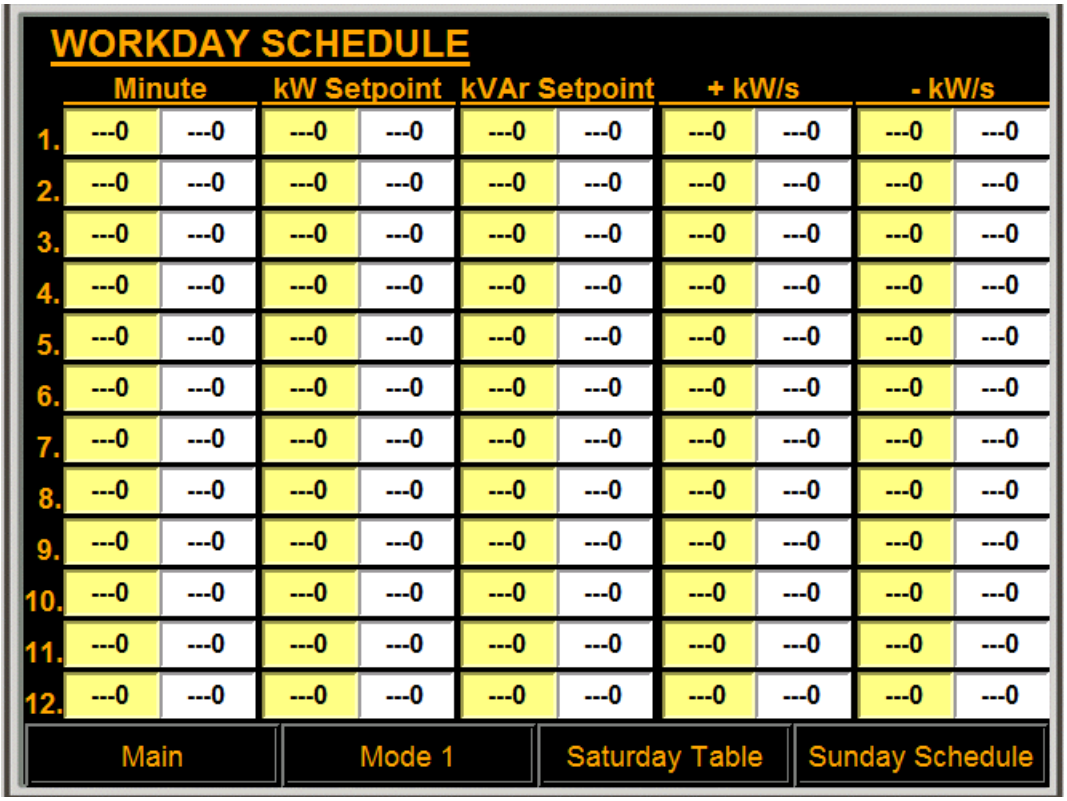
8. MODE 1 - TIME TABLE SCHEDULE (TTS) MODE

In this mode the ABB Control System will perform peak load shaving based on a fixed time schedule. Break set points are received from the Customer over the Modbus TCP/IP communication network. The time schedule is set in advance but adjustments can be done during system operation also.
To synchronize time between the ABB Control System and the Customer a customer provided GPS SNTP device will be used.

Time break points will be in minutes per 24 hour period ranging from 0-1439. The table will allow the operator to set a total of 12 break points per 24 hour period. For example a value of 130 minutes is corresponding to 2:10 AM.

To accommodate different load profiles three different Time Tables will be used:

- Workday schedule (DOW = 1,2,3,4,5 or Monday to Friday)
- Saturday schedule (DOW = 6)
- Sunday schedule (DOW = 7)

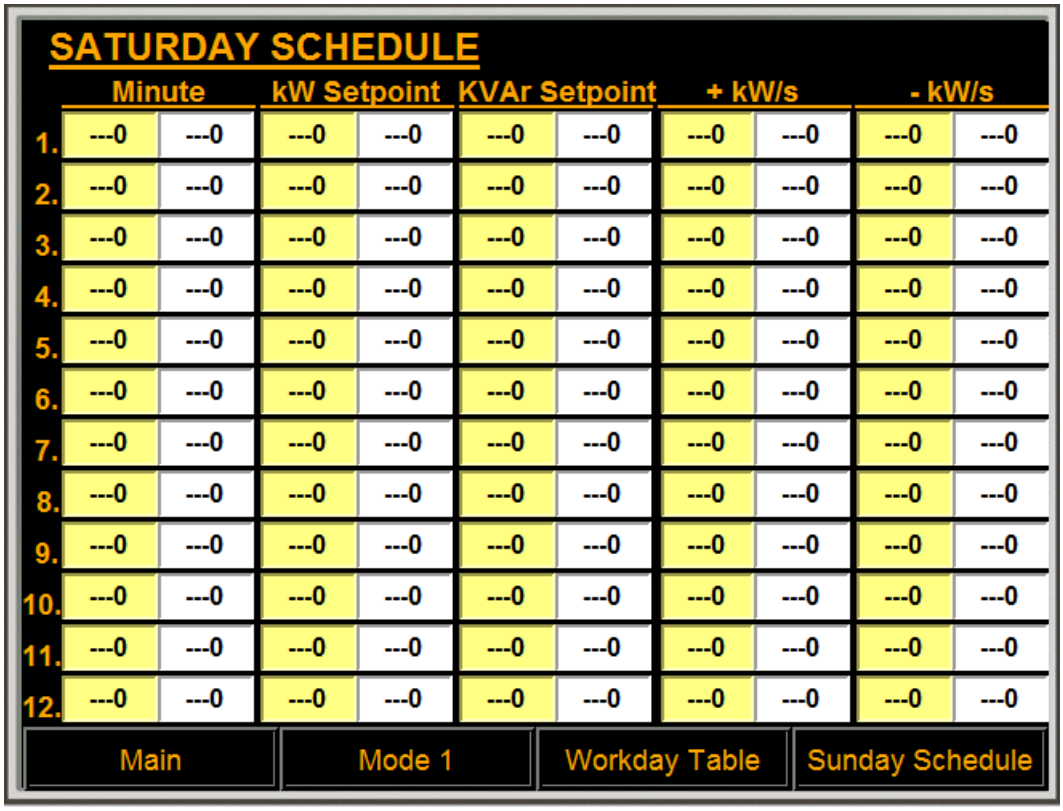


WORKDAY SCHEDULE

	Minute		kW Setpoint		kVAr Setpoint		+ kW/s		- kW/s	
1.	---0	---0	---0	---0	---0	---0	---0	---0	---0	---0
2.	---0	---0	---0	---0	---0	---0	---0	---0	---0	---0
3.	---0	---0	---0	---0	---0	---0	---0	---0	---0	---0
4.	---0	---0	---0	---0	---0	---0	---0	---0	---0	---0
5.	---0	---0	---0	---0	---0	---0	---0	---0	---0	---0
6.	---0	---0	---0	---0	---0	---0	---0	---0	---0	---0
7.	---0	---0	---0	---0	---0	---0	---0	---0	---0	---0
8.	---0	---0	---0	---0	---0	---0	---0	---0	---0	---0
9.	---0	---0	---0	---0	---0	---0	---0	---0	---0	---0
10.	---0	---0	---0	---0	---0	---0	---0	---0	---0	---0
11.	---0	---0	---0	---0	---0	---0	---0	---0	---0	---0
12.	---0	---0	---0	---0	---0	---0	---0	---0	---0	---0

Main | Mode 1 | Saturday Table | Sunday Schedule

Mode 1 - Workday schedule

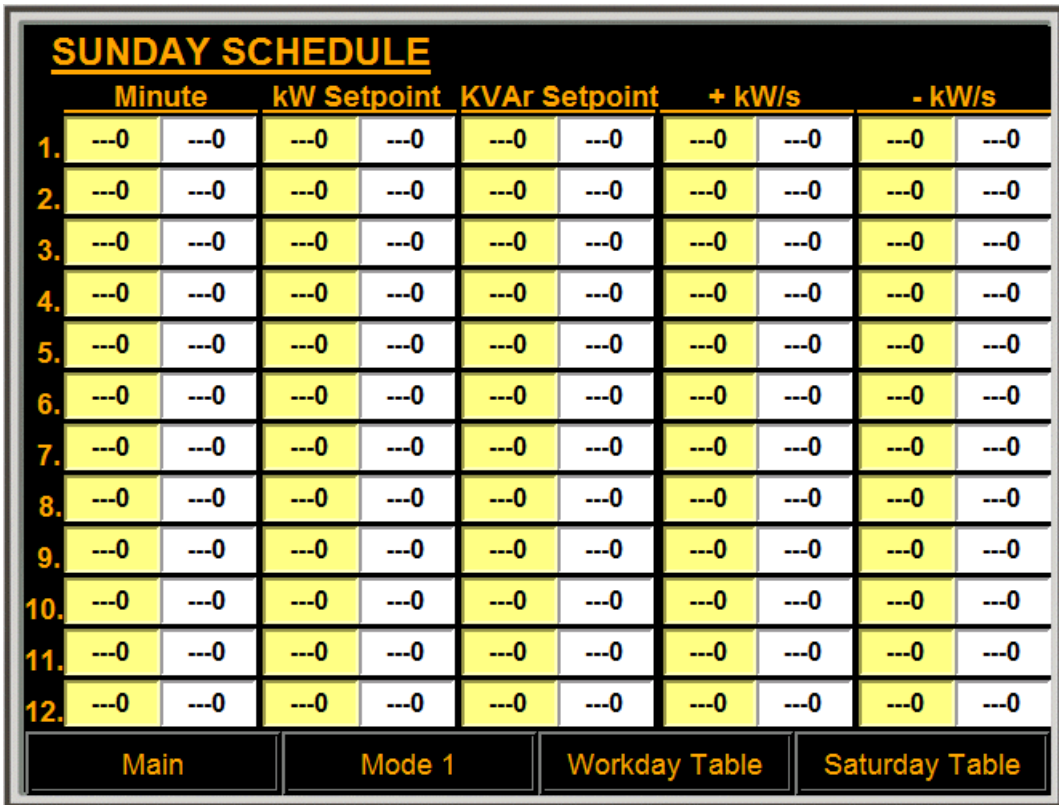


SATURDAY SCHEDULE

	Minute		kW Setpoint		KVAr Setpoint		+ kW/s		- kW/s	
1.	---0	---0	---0	---0	---0	---0	---0	---0	---0	---0
2.	---0	---0	---0	---0	---0	---0	---0	---0	---0	---0
3.	---0	---0	---0	---0	---0	---0	---0	---0	---0	---0
4.	---0	---0	---0	---0	---0	---0	---0	---0	---0	---0
5.	---0	---0	---0	---0	---0	---0	---0	---0	---0	---0
6.	---0	---0	---0	---0	---0	---0	---0	---0	---0	---0
7.	---0	---0	---0	---0	---0	---0	---0	---0	---0	---0
8.	---0	---0	---0	---0	---0	---0	---0	---0	---0	---0
9.	---0	---0	---0	---0	---0	---0	---0	---0	---0	---0
10.	---0	---0	---0	---0	---0	---0	---0	---0	---0	---0
11.	---0	---0	---0	---0	---0	---0	---0	---0	---0	---0
12.	---0	---0	---0	---0	---0	---0	---0	---0	---0	---0

Main | Mode 1 | Workday Table | Sunday Schedule

Mode 1 - Saturday schedule



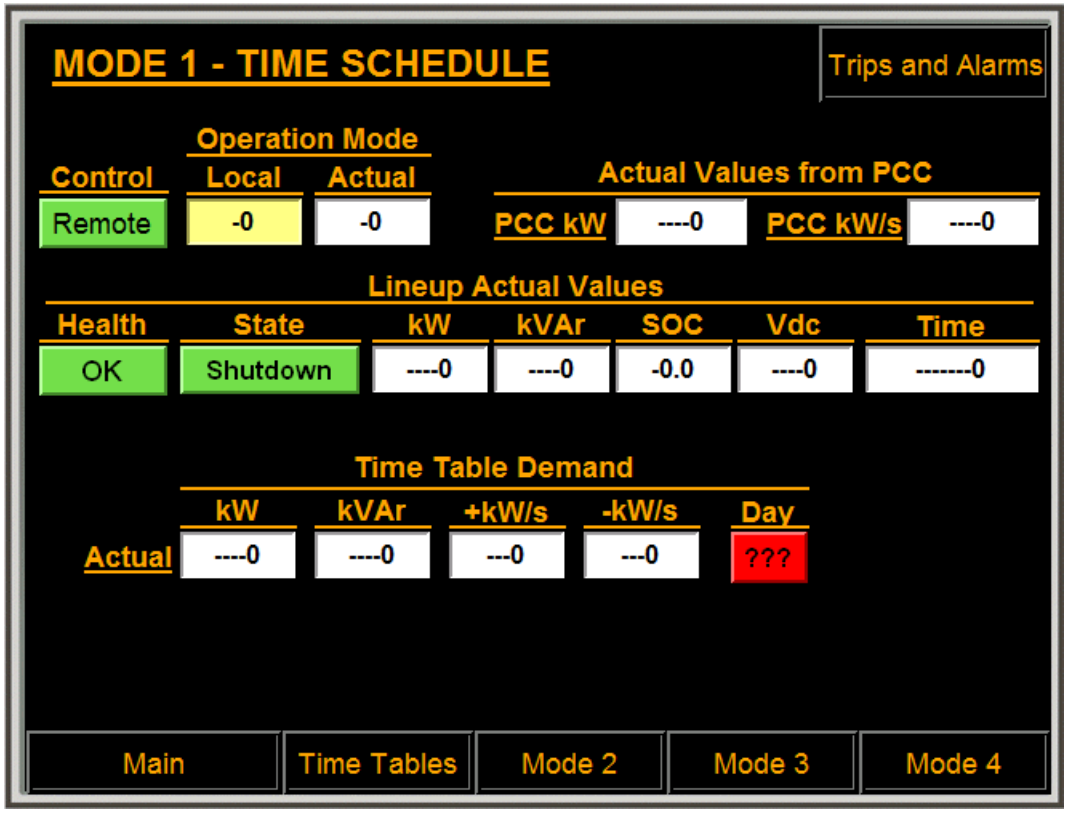
Mode 1 - Sunday schedule

DAY SCHEDULE TABLES are used to enter set points locally or to review set points received from customer over communication network.

- **Minute break point** (yellow) – Time (minute) set point set from HMI and used in Local mode.
- **Minute break point** (white) – Time (minute) set point received from Customer over TCP/IP network and used in Remote mode.
- **kW Set point** (white) – P (kW) set point set from HMI and used in Local mode.
- **kW Set point** (yellow) – P (kW) set point received from Customer over TCP/IP network and used in Remote mode.
- **kVAr Set point** (white) – Q (kVAr) set point set from HMI and used in Local mode.
- **kVAr Set point** (yellow) – Q (kVAr) set point received from Customer over TCP/IP network and used in Remote mode.
- **+kW/s Set point** (white) – dP/dt (kW/s) discharge slope set point set from HMI and used in Local mode.

- **+kW/s Set point** (yellow) – dP/dt (kW/s) discharge slope set point received from Customer over TCP/IP network and used in Remote mode.
- **-kW/s Set point** (white) – dP/dt (kW/s) charge slope set point set from HMI and used in Local mode.
- **-kW/s Set point** (yellow) – dP/dt (kW/s) charge slope set point received from Customer over TCP/IP network and used in Remote mode.

After Time Break Points have been populated MODE ***1 – TIME SCHEDULE*** screen is used for overview of the process.



Mode 1 Time Schedule Screen

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1. **Operation Mode**
   - **Local** – Operation mode requested locally from HMI.
   - **Actual** – Actual system operating mode
2. **Control**
   - **Remote** – The ABB System is taking commands from remote client communication
   - **Local** – The ABB System is controlled from local HMI.

3. **Actual Values from PCC**
    - **PCC kW** – Actual kW load measured at the PCC compensated with the BES output.
    - **PCC kW/s** – Calculated load rate of change (slope)
4. **Lineup Actual Values**

    Health
    - **OK:** indicates that there is no problem with the lineup.
    - **Alarm:** indicates an active alarm within the lineup.
    - **Fault:** indicates that lineup has experienced a serious fault and is tripped.

    State
    - **Shutdown:** AC and DC breakers are opened and inverters are stopped.
    - **Ready:** Lineup is at shutdown but ready to receive enable command.
    - **Enabled:** Lineup is ready to receive run command.
    - **Online:** Lineup is ready to receive a power reference.
    - **Standby:** Lineup has slipped into standby mode if power reference was below standby limit for defined time.
    - **Transition:** Lineup is at transition state between the defined states.

    - **kW** - Lineup Active power (positive is power out to the grid therefore discharging batteries and negative is power in from the grid therefore charging batteries).
    - **kVAr** - Lineup Reactive power (positive is capacitive and negative is inductive reactive).
    - **SOC** – SOC received from the battery.
    - **VDC** – DC bus voltage measured by the inverter.
    - **Time** – Remaining battery life if discharge is continued with same rate (set point)

5. **Time Table Demand**
    - **kW** – Actual used P (kW) set point.
    - **kVAr** – Actual used Q (kVAr) set point.
    - **+kW/s** – Actual used charge slope (kW/s) set point.
    - **-kW/s** – Actual used discharge slope (kW /s) set point.
    - **Day** – Actual day of the week.

Table below is example of the one work day (WD) Break Set Point received from the Customer over the communication network.

Name	Unit	Description
Time_WD_Sp_1	min	Time break point in minutes (200 = 3:20 AM)
P_WD_Sp_1	kW	Active power P set point in kW
Q_WD_Sp_1	kVAr	Reactive power Q set point in kVAr
dPdt_P_WD_Sp_1	kW/sec	Positive (discharge) ramp rate in kW/sec (Slope)
dPdt_N_WD_Sp_1	kW/sec	Negative (charge) ramp rate in kW/sec (Slope)

Table - Time Break Point sample

The Customer will set Operation Mode request (OMr) to 1 and the ABB Control System will reply by returning back same value as the Operation Mode (OM) actual confirming that the ABB Control System is ready. If OM is not equal to 1 the ABB Control System is not ready and the operator will need to check alarm and fault messages.

Actual feeder load Pm is not required in this mode.

The Customer will enable BES charging by entering a negative value to the Active Power (Pr) set point. The ABB Control System will perform an automatic battery charge sequence during that time. The charge cycle ends if the BES SOC =100% or Active power (Pr) set point become zero or higher value.

The Customer has an option to limit power during charging cycle by reducing Active Power (Pr) set point less than maximum value of -500 kW. During operation the ABB Control System is monitoring and limiting charge or discharge power level required by the BES or by ABB PCS in order to prevent possible damage to the system.

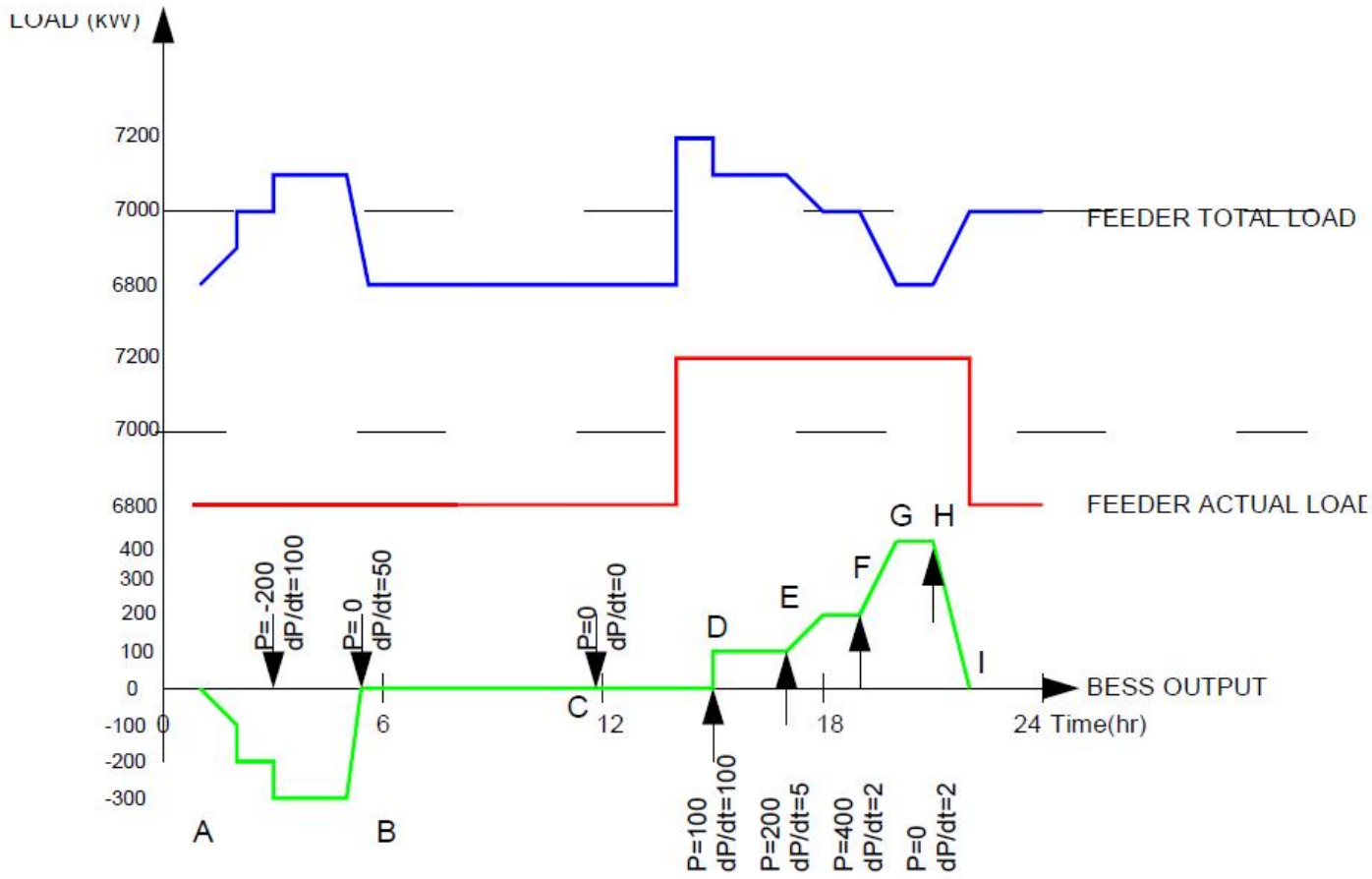
When the charge cycle is competed the ABB Control System will stop charging and stay online waiting for discharge cycle to begin. Maximum rate of change (slope) is controlled by the Slope plus or Slope minus values obtained from the table. If the corresponding table value is zero the ABB Control System will not transition to the new set point.

The ABB Control System will also notify operator if the discharging cycle is coming to the end with two alarms. The first alarm is based on the SOC and it will inform the operator when the batteries are below 10% capacity (adjustable). The second alarm is based on the remaining discharge time and it will inform the operator when there is only 10min (adjustable) left while discharging with the same rate.

For illustration purposes dP/dt is exaggerated as kW/hour but the ABB Control System will operate with kW/sec during operation.

Item	Time Break Point (Min)	Active Power (kW)	Reactive Power (kVAr)	Charge Ramp (minus) (kW/sec)	Discharge Ramp (plus) (kW/sec)
1	0	0	0	0	0
2	60	-100	0	5	0
3	120	-200	0	100	0
4	180	-300	0	100	0
5	300	0	0	0	50
6	900	100	0	0	100
7	1020	200	0	0	5
8	1140	400	0	0	2
9	1260	0	0	2	0
10	0	0	0	0	0
11	0	0	0	0	0
12	0	0	0	0	0

Mode 1- Work Day Table Setting Example



Mode 1- Time Table Schedule Operation Example

9. MODE 2: REMOTE CONTROL (RC) MODE

In this mode the ABB Control System is controlling BES energy flow based on the real time power set point. The purpose of this mode is to enable the Customer to utilize its own smart energy management system to remote control the BES. In the remote mode power set point is received from the Customer over the communication network.

Table below is example Set Point received from the Customer over the communication network.

Name	Unit	Description
Pr	kW	Active power P set point in kW
Qr	kVAr	Reactive power Q set point in kVAr
dPp/dtr	kW/sec	Positive (discharge) ramp rate in kW/sec (Slope)
dPn/dtr	kW/sec	Negative (charge) ramp rate in kW/sec (Slope)

Mode 2- Signal Exchange Description

In the local mode power set point is controlled from the local HMI.

The Customer will set Operation Mode request (OMr) to 2 and the ABB Control System will reply by returning back same value as the Operation Mode (OM) actual confirming that the ABB Control System is ready. If OM is not equal to 2 the ABB Control System is not ready and operator needs to check alarm and fault messages.

The ABB PCS will discharge the BES using Active and Reactive Power set points received from Customer in real time. During operation the ABB control system will also limit charge or discharge power if required by the BES or by ABB PCS, to prevent possible harm to the system.

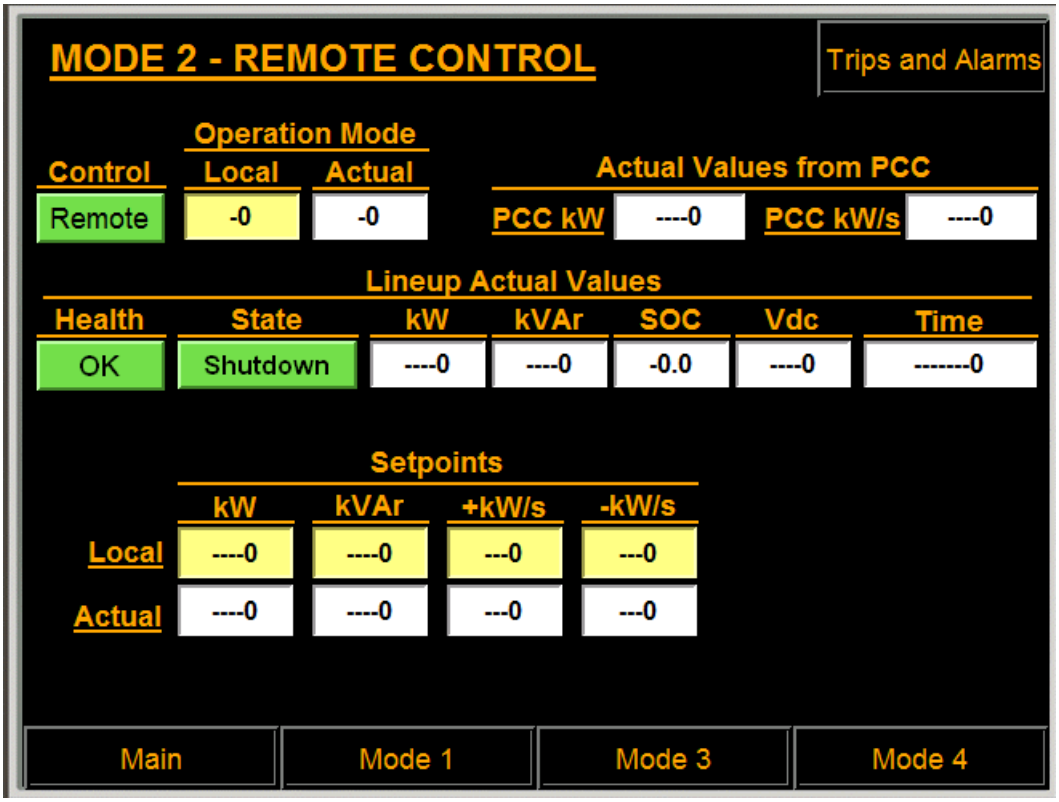
The ABB Control System will also notify the operator if the discharge cycle is coming to the end with two alarms. The first alarm is based on the SOC and it will inform the operator when the batteries are below 10% capacity (adjustable). The second alarm is based on the remaining discharge time and it will inform the operator when there is only 10min (adjustable) left, if discharging with the same rate.

The Customer will enable the BES charging by entering an active power set point (Pr) to a negative value. The ABB Control System will start a full automatic battery charge sequence. The charging cycle will always

be carried out using maximum available power. The Customer has the option to limit power during charging cycle if Pr value is set less than maximum charging value of -500 kW. Once the charge cycle is competed (BES SOC=100%), the ABB Control System will stop charging and inhibit inverters waiting for discharge cycle to begin.

Time synchronization (TSP) and Actual feeder load Pm are not required in this mode.

MODE 2 **– *REMOTE CONTROL*** screen is used for overview of the process.



Mode 2 Operator Control Screen

1. **Operation Mode**
    - **Local** – Operation mode requested locally from HMI.
    - **Actual** – Actual system operating mode
2. **Control**
    - **Remote** – The ABB System is taking commands from remote client communication
    - **Local** – The ABB System is controlled from local HMI.
3. **Actual Values from PCC**
    - **PCC kW** – Actual kW load measured at the PCC compensated with the BES output.
    - **PCC kW/s** – Calculated load rate of change (slope)
4. **Lineup Actual Values**

    Health
    - **OK:** indicates that there is no problem with the lineup.
    - **Alarm:** indicates an active alarm within the lineup.
    - **Fault:** indicates that lineup has experienced a serious fault and is tripped.

    State
    - **Shutdown:** AC and DC breakers are opened and inverters are stopped.
    - **Ready:** Lineup is at shutdown but ready to receive enable command.
    - **Enabled:** Lineup is ready to receive run command.
    - **Online:** Lineup is ready to receive a power reference.
    - **Standby:** Lineup has slipped into standby mode if power reference was below standby limit for defined time.
    - **Transition:** Lineup is at transition state between the defined states.

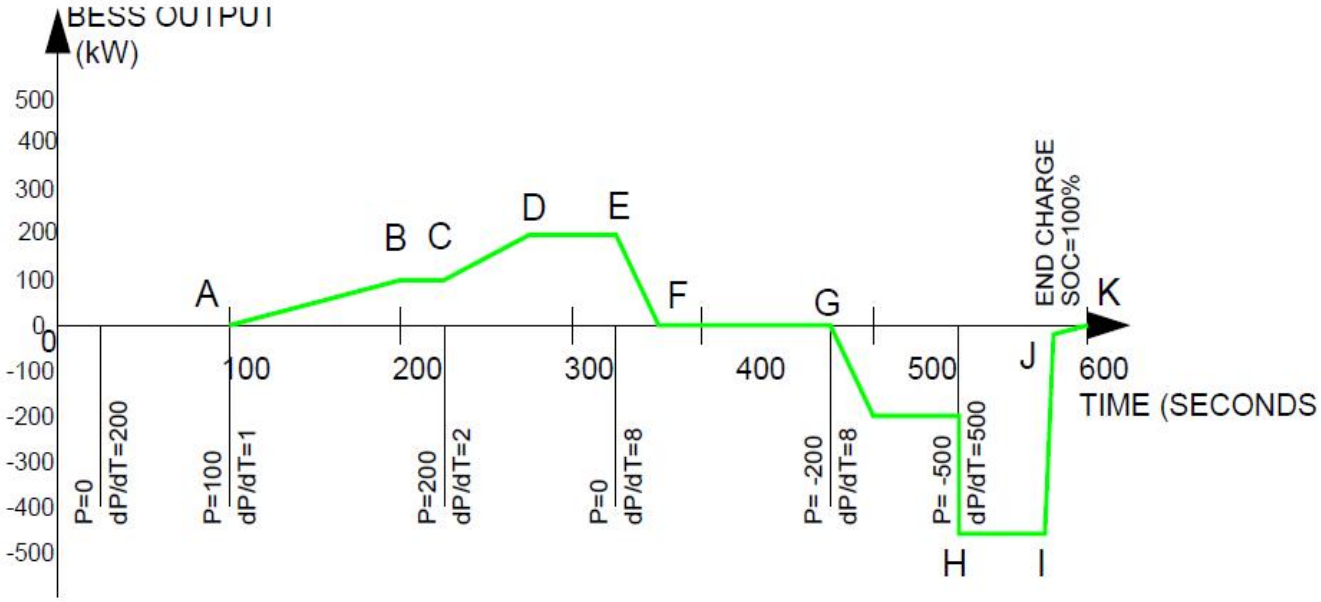
    - **kW** - Lineup Active power (positive is power out to the grid therefore discharging batteries and negative is power in from the grid therefore charging batteries).
    - **kVAr** - Lineup Reactive power (positive is capacitive and negative is inductive reactive).
    - **SOC** – SOC received from the battery.
    - **VDC** – DC bus voltage measured by the inverter.
    - **Time** – Remaining battery life if discharge is continued with same rate (set point)

5. **Set points**

Local (yellow) field are set points intended for the operator to enter the value in local control mode.

Actual (white) fields are actual system set points. In the local control mode actual and local set points are the same. In the remote control mode actual set points will present customer remote set point values.

- **kW** – Actual used P (kW) set point.
- **kVAr** – Actual used Q (kVAr) set point.
- **-kW/s** – Actual used charge slope (kW/s) set point.
- **+kW/s** – Actual used discharge slope (kW /s) set point.



Mode 2- Operation Example

10. MODE 3: PEAK LOAD SHAVING – AUTOMATIC MODE

In this mode system the ABB Control System is automatically performing peak load shaving based on the following set point values received from the Customer over the communication network.

Actual feeder load Pm is required for this mode of operation. Customer is responsible to provide PCC actual power signal to the ABB control system

Time synchronization (TSP) is required in this mode. To synchronize time between the ABB Control System and the Customer a customer provided GPS SNTP device will be used.

Name	Unit	Description
Phr	(0-xx)kW	Active power set point limit. If power at the PCC exceeds set point Phr the ABB Control System will start to discharge the BES keeping load at Phr level. When measured load at PCC falls below Phr level the ABB Control System will stop discharging.
dPp/dtr	kW/sec	Positive (discharge) ramp rate in kW/sec (Slope)
dPn/dtr	kW/sec	Negative (charge) ramp rate dP/dt in kW/sec (Slope)
PFr	(-)1-0-1	BES output Power factor. PFr is used to calculate Q (kVAr) during automatic regulation. Qout=Pout * PFpr. (Positive = inductive load)
Tdr	sec	Time delay after power demand exceeds Phr to start regulating
SOCr	0-100%	Set value for BES SOC when equalizing battery in auto mode.
Pcr	(0 to -500)kW	BES equalizing power limit
TcrStart	minute	Start equalizing time – minutes (TcsStart<TcrStop)
TcrStop	minute	Stop equalizing time – minutes (TcsStart>TcrStop)

Mode 3- Signal Exchange Description

Regulation Cycle

The Customer will set Operation Mode request (OMr) to 3 and the ABB Control System will reply by returning back same value as the Operation Mode (OM) actual confirming that the ABB Control System is

ready. If OM is not equal to 3 the ABB Control System is not ready and the operator needs to check alarm and fault messages.

The ABB Control System is monitoring load at the PCC. If load power at the PCC would exceed set point Phr, the ABB Control System will start to discharge the BES after time delay defined by Tdr. During regulation cycle the ABB Control System will maintain load at Phr level as long as the PCS or BES is able to provide required power output. When measured load at PCC falls below Phr level the ABB Control System will stop discharge. The ABB Control System will also notify the operator if the discharge cycle is coming to the end with two alarms. The first alarm is based on the SOC and it will inform the operator when the batteries are below 10% capacity (adjustable). The second alarm is based on the remaining discharge time and it will inform the operator when there is only 10min (adjustable) left while discharging with the same rate.

Power factor set point (PFr) is a value that the ABB Control System will use to define ratio between active and reactive power supplied at the PCC. Positive PFr is corresponding to inductive and negative is corresponding to capacitive reactive power. The ABB Control System is NOT regulating PF at the PCC.

Equalize Cycle

The purpose of the equalizing cycle is to enable the ABB Control system to automatically charge or discharge BES in order to reach the Customer SOCr set point.

Start and Stop equalize time Setpoint are received from the customer in minutes. For example value of 130 minutes is corresponding to 2:10 AM.

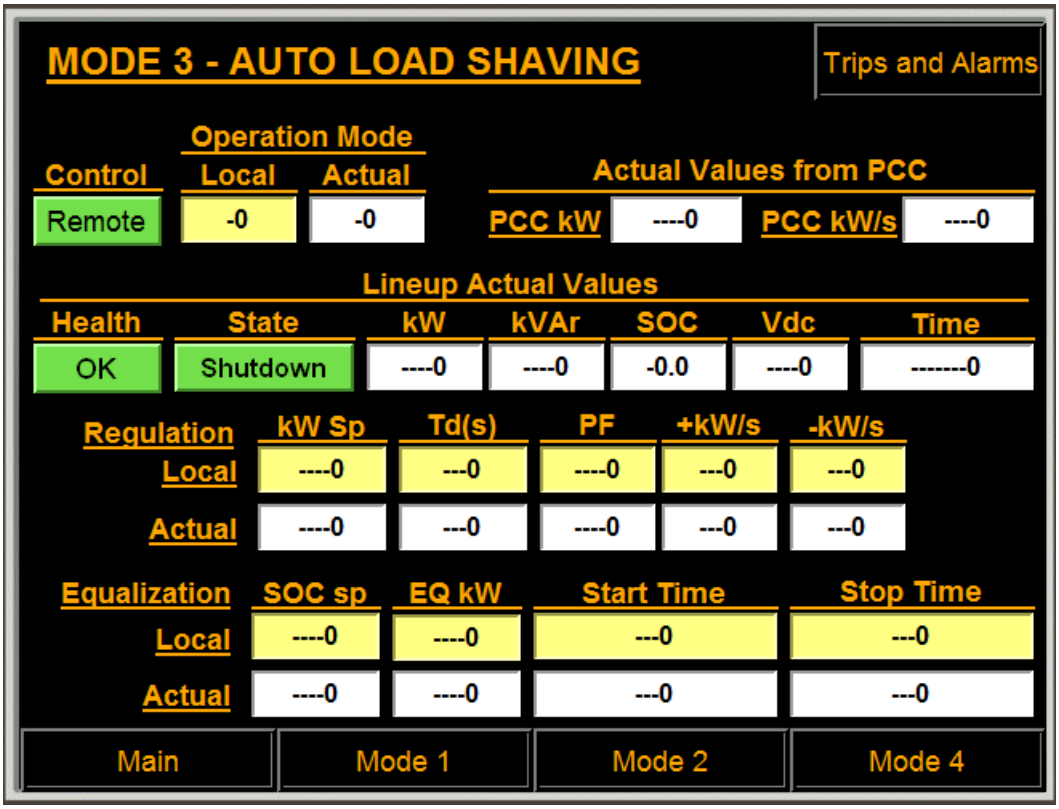
The Operator will define Start and End of equalize time. During that period the ABB Control System will equalize the BES until set point SOCr is achieved. When the BES reaches SOCr, the ABB Control System will inhibit operation and wait for a new peak load shave cycle to start. Battery charge power limit at all time is controlled by the lowest of three values:

- BES current limit
- PCS system internal power limits (inverter temperature, transformer temperature, Inverter module fault etc.)
- Customer equalize power limit (Pcr value in kW).

If the system would not reach SOCr during the expected period of time the ABB Control System will activate an alarm.

Following is example of the Peak Load Shaving cycle. Ph = 7000 kW.

MODE 3 **– *AUTOMATIC LOAD SHAVING*** screen is used for overview of the process.



1. **Operation Mode**
   - **Local** – Operation mode requested locally from HMI.
   - **Actual** – Actual system operating mode
2. **Control**
   - **Remote** – The ABB System is taking commands from remote client communication
   - **Local** – The ABB System is controlled from local HMI.
3. **Actual Values from PCC**
   - **PCC kW** – Actual kW load measured at the PCC compensated with the BES output.
   - **PCC kW/s** – Calculated load rate of change (slope)
4. **Lineup Actual Values**

Health

- **OK:** indicates that there is no problem with the lineup.
- **Alarm:** indicates an active alarm within the lineup.
- **Fault:** indicates that lineup has experienced a serious fault and is tripped.

State

- **Shutdown:** AC and DC breakers are opened and inverters are stopped.
- **Ready:** Lineup is at shutdown but ready to receive enable command.
- **Enabled:** Lineup is ready to receive run command.
- **Online:** Lineup is ready to receive a power reference.
- **Standby:** Lineup has slipped into standby mode if power reference was below standby limit for defined time.
- **Transition:** Lineup is at transition state between the defined states.

- **kW** - Lineup Active power (positive is power out to the grid therefore discharging batteries and negative is power in from the grid therefore charging batteries).
- **kVAr** - Lineup Reactive power (positive is capacitive and negative is inductive reactive).
- **SOC** – SOC received from the battery.
- **VDC** – DC bus voltage measured by the inverter.
- **Time** – Remaining battery life if discharge is continued with same rate (set point)

5. **Regulation**

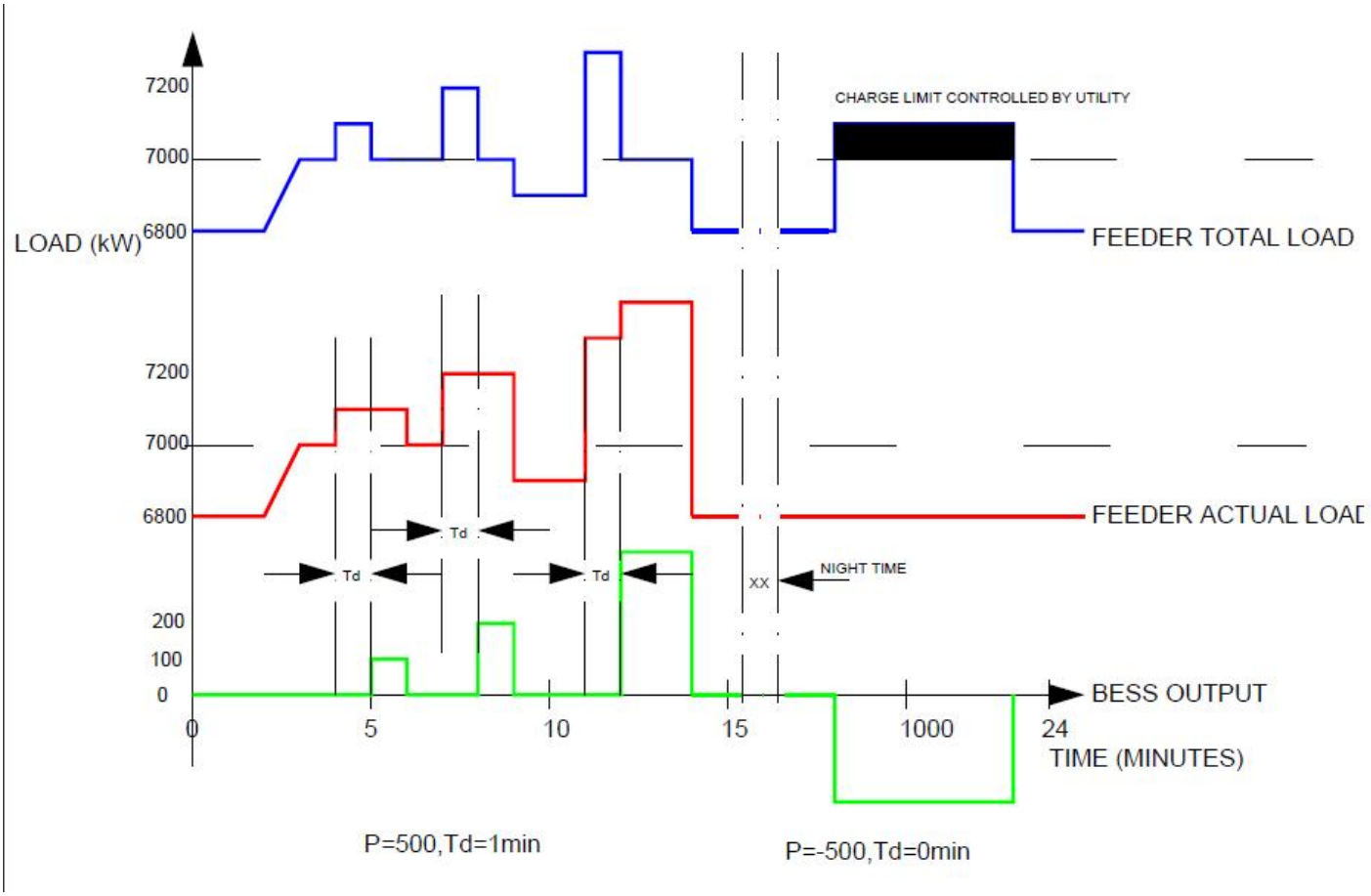
Local (yellow) field are set points intended for the operator to enter the value in Local control mode. Actual (white) fields are actual system set points. In the Local control mode actual and local set points are the same. In the Remote control mode actual set points will present customer remote set point values.

- **kW Sp** – PCC Actual load set point (kW) to start regulation.
- **Td (s)** – Time delay required for actual load at PCC to continually exceed kW Sp set point before the ABB control system starts regulating peak load.
- **PF** – BES output Power factor. Used to calculate BES reactive power output. Q=P*PF
- **-kW/s** – Actual used charge slope (kW/s) set point.
- **+kW/s** – Actual used discharge slope (kW /s) set point.

6. **Equalization**

Local (yellow) field are set points intended for the operator to enter the value in the Local control mode. Actual (white) fields are actual system set points. In the Local control mode actual and local set points are the same. In the Remote control mode actual set points will present the Customer remote set point values.

- **SOC sp** – BES SOC set point during equalization.
- **EQ kW** – Power limit set point during equalization (same for charge and discharge mode).
- **Start Time** – Equalization start time in min.
- **Stop Time** – Equalization stop time in min.



Mode 3- Operation Example

11. MODE 4: LOAD SMOOTHING – AUTOMATIC MODE

In this mode system the ABB Control System is automatically performing load smoothing measured at the PCC based on the following set point values received from the Customer over the communication network.

Mode 4- Signal Exchange Description

Name	Unit	Description
Pm	kW	Feeder measured load. The ABB Control System will receive it as analog input
dPp/dtr	kW/sec	Maximum allowed Positive rate of change. When actual measured load dPm/dt is higher then dPp/dt the ABB Control System start will discharge BES.
dPn/dtr	kW/sec	Maximum allowed Negative rate of change. When actual measured load dPm/dt is higher then dPp/dt the ABB Control System start will charging BES.
PFpr	0-1-0	Power factor set by the Customer used to calculate Q (kVAr) during positive transients smoothing (battery discharge). Qout=Pout * PFpr
PFnr	0-1-0	Power factor set by the Customer used to calculate Q (kVAr) during negative transients smoothing (battery charge). Qout=Pout * PFnr.
SOCr	0-100%	Set value for SOC when battery is not working in auto mode (transient smoothing)
Pcr	(0 to -500) kW	Power limit (between zero and -500 kW) the ABB Control System will use to charge the battery.
TcrStart	minute	Start charge time – minutes (TcsStart<TcrStop)
TcrStop	minute	Stop charge time – minutes (TcsStart>TcrStop)

Actual feeder load Pm is required for this mode of operation. Customer is responsible to provide PCC actual power signal to the ABB control system.

Time synchronization (TSP) is required in this mode. To synchronize time between the ABB Control System and the Customer a customer provided GPS SNTP device will be used.

The Customer will set Operation Mode request (OMr) to 4 and the ABB Control System will reply by returning back same value as the Operation Mode (OM) actual confirming that the ABB Control System is ready. If OM is not equal to 4 the ABB Control System is not ready and the operator needs to check alarm and fault messages.

Regulation Cycle

In this mode the ABB Control System will perform smoothing during the load transitions only. Since load smoothing is performed both ways during sharp rise or sharp fall of the load it is ideal to have battery SOC at approximately 50% before the cycle starts.

The ABB Control System is monitoring feeder actual load Pm (received as analog input) and calculating dP/dt in kW/s. When load change rate is greater than set point dPp/dt or dPn/dt (consuming or generating) the ABB Control System will smooth the feeder load by injecting or absorbing the power at the PCC with opposite rate of change. Once dP/dt falls below set point the ABB Control System will slowly start decreasing power output to zero. The rate at which this occurs will be defined during commissioning. In case a new transition occurs during the decreasing period the ABB Control System will resume regulation to smooth the transition.

In case that full power limit is reached during regulation (+/- 500kW) no further load smoothing is possible and the ABB Control System will automatically start to decrease power output to zero.

Power factor set point (PFr) is a value that the ABB Control System will use to define ratio between active and reactive power supplied at the PCC. Positive PFr is corresponding to inductive and negative is corresponding to capacitive reactive power. The ABB Control System is NOT regulating PF at the PCC.

Equalize Cycle

It is important to note that during equalizing mode the ABB Control system will perform automatic charge or discharge in order to reach Customer SOCr set point.

Start and Stop equalize time set points are received from the Customer in minutes. For example value of 130 minutes is corresponding to 2:10 AM.

Operator will set Start and End of equalize time. During that period of time the ABB Control System will equalize BES until set point SOCr is achieved. When BES reaches SOCr the ABB Control System will inhibit operation and wait for new peak load shave cycle to start. Battery charge power limit at any time is controlled by lowest of three values:

BES current limit

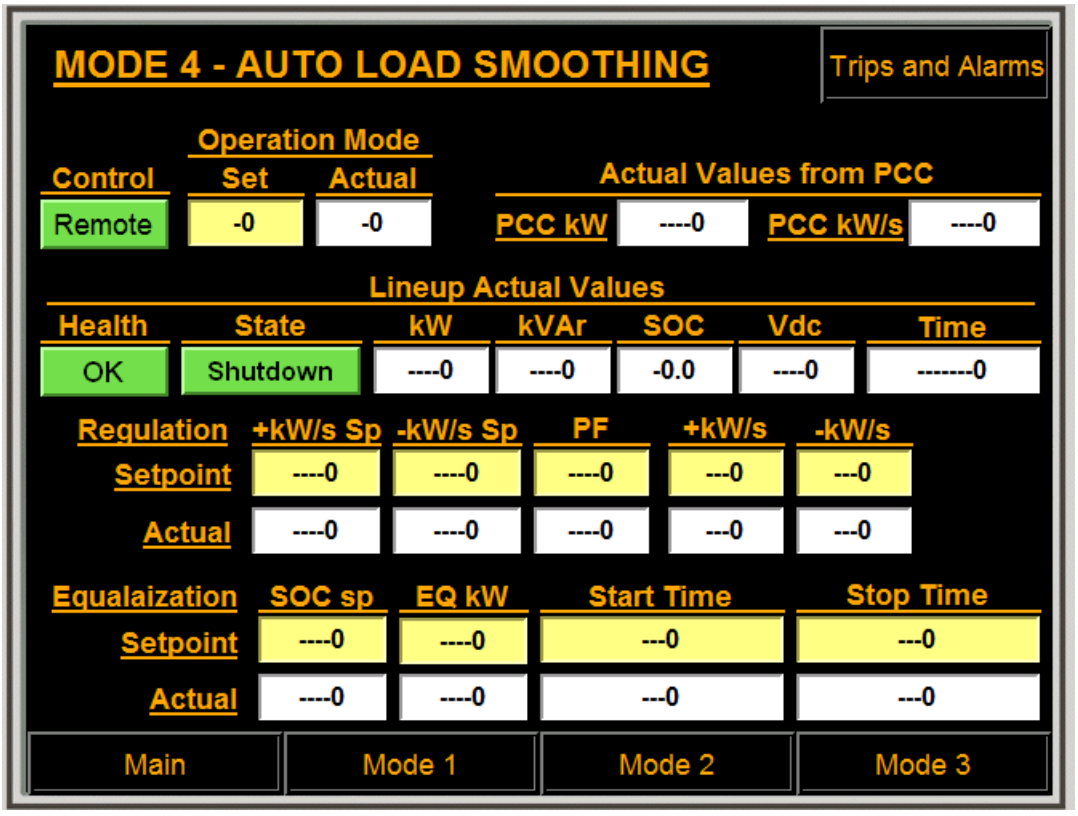
PCS system internal power limits (inverter temperature, transformer temperature, Inverter module fault etc.)

Customer equalize power limit (Pcr value in kW).

If during allotted period of time system would not reach SOCr the ABB Control System will activate alarm.

Following is an example of the smoothing cycle.

Following screen is designed to be used with Mode 4 – ***AUTO LOAD SMOOTHING***



1. **Operation Mode**
   - **Local** – Operation mode requested locally from HMI.
   - **Actual** – Actual system operating mode
2. **Control**

- **Remote** – The ABB System is taking commands from remote client communication
- **Local** – The ABB System is controlled from local HMI.

3. **Actual Values from PCC**
   - **PCC kW** – Actual kW load measured at the PCC compensated with the BES output.
   - **PCC kW/s** – Calculated load rate of change (slope)
4. **Lineup Actual Values**

   Health
   - o **OK:** indicates that there is no problem with the lineup.
   - o **Alarm:** indicates an active alarm within the lineup.
   - o **Fault:** indicates that lineup has experienced a serious fault and is tripped.

   State
   - o **Shutdown:** AC and DC breakers are opened and inverters are stopped.
   - o **Ready:** Lineup is at shutdown but ready to receive enable command.
   - o **Enabled:** Lineup is ready to receive run command.
   - o **Online:** Lineup is ready to receive a power reference.
   - o **Standby:** Lineup has slipped into standby mode if power reference was below standby limit for defined time.
   - o **Transition:** Lineup is at transition state between the defined states.

   - **kW** - Lineup Active power (positive is power out to the grid therefore discharging batteries and negative is power in from the grid therefore charging batteries).
   - **kVAr** - Lineup Reactive power (positive is capacitive and negative is inductive reactive).
   - **SOC** – SOC received from the battery.
   - **VDC** – DC bus voltage measured by the inverter.
   - **Time** – Remaining battery life if discharge is continued with same rate (set point)

6. **Regulation**

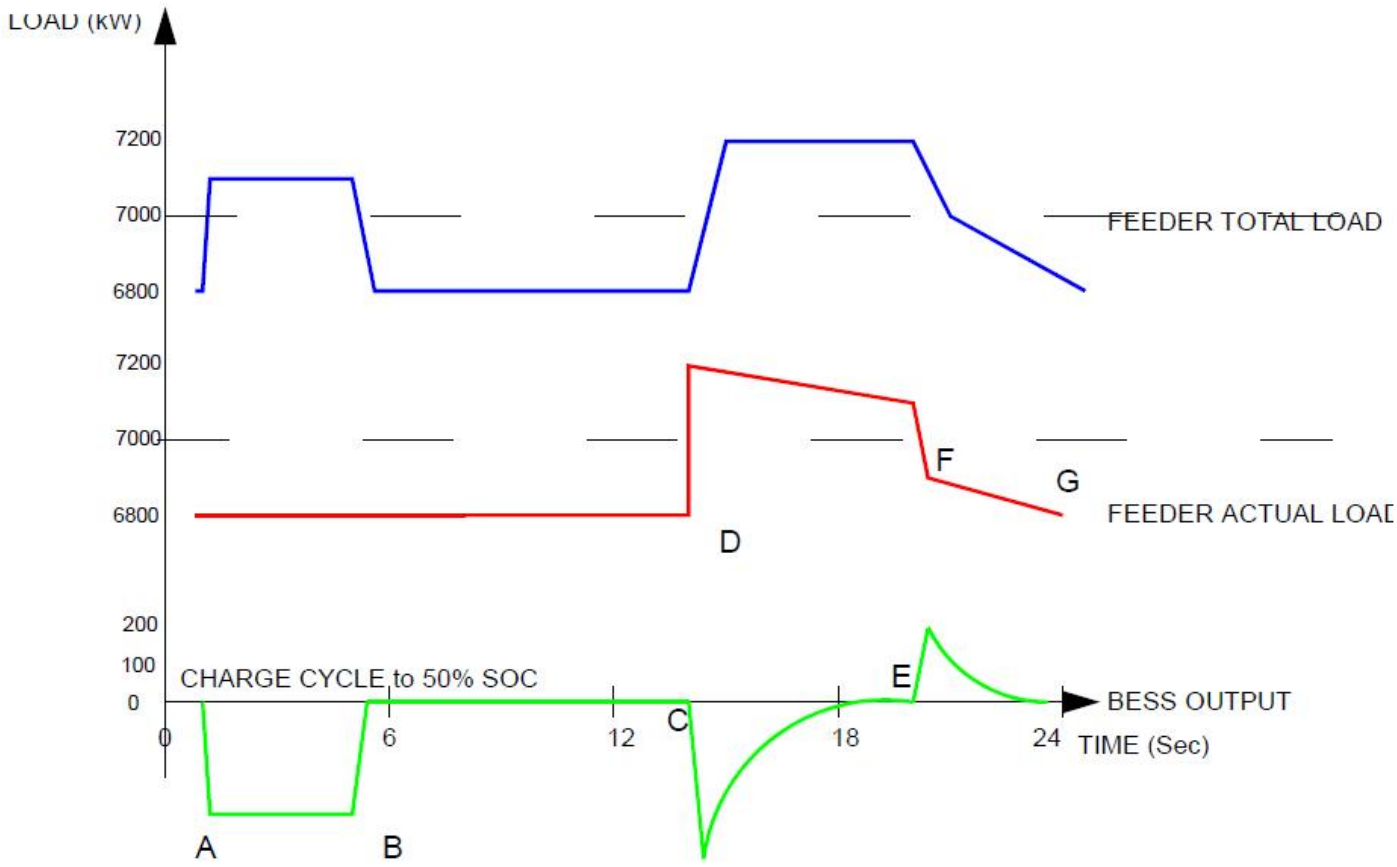
Local (yellow) field are set points intended for the operator to enter the value in Local control mode. Actual (white) fields are actual system set points. In the Local control mode actual and local set points are the same. In the Remote control mode actual set points will present customer remote set point values.

- **+kW/s Sp** – Maximum allowed Positive rate of change. When actual calculated load kW/s is higher than kW/s Sp the ABB Control System start will discharge BES.
- **-kW/s Sp** – Maximum allowed Negative rate of change. When actual calculated load kW/s is higher than kW/s Sp the ABB Control System start will charge BES.
- **PF** – BES output Power factor. Used to calculate BES reactive power output. Q=P*PF
- **-kW/s** – Actual calculated charge slope (kW/s) at the PCC.
- **+kW/s** – Actual calculated discharge slope (kW /s) at the PCC.

7. **Equalization**

Local (yellow) field are set points intended for the operator to enter the value in the Local control mode. Actual (white) fields are actual system set points. In the Local control mode actual and local set points are the same. In the Remote control mode actual set points will present the Customer remote set point values.

- **SOC sp** – BES SOC set point during equalization.
- **EQ kW** – Power limit set point during equalization (same for charge and discharge mode).
- **Start Time** – Equalization start time in min.
- **Stop Time** – Equalization stop time in min.



Mode 4- Operation Example

REVISION HISTORY

REVISIONS TABLE

REV IND	DATE	DESCRIPTION	REV BY
0	04/20/2012	FIRST ISSUE	JM